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Remedial Investigation/ Feasibility Study Work Plan for the 100-KR-4 Operable Unit, Hanford Site, Richland, Washington

Environmental Division

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Department of Energy
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LIST OF ACRONYMS

ACL	alternate concentration limits
ADI	acceptable daily intake
ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
ATSM	American Society of Mechanical Engineers
ATSDR	Agency for Toxic Substances and Disease Registry
BTDS BWIP	technical data system
BWIP	Basalt Waste Isolation Project
CAA	Clean Air Act
CCS	commitment control system
CDR	conceptual design report
CEQ	Council on Environmental Quality
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	Code of Federal Regulations
CLP	contract laboratory program
CMD	corrective measures design
CMI	corrective measures implementation
CMS	corrective measures study
CPP	CERCLA past practice
CRDL	contract-required detection of limits
CRP	Community Relations Plan
CZMA	Coastal Zone Management Act
D&D	decommissioning and decontamination
DAC	derived air concentration
DCG	derived concentration guides
DHHS	Department of Health and Human Services
DMP	Data Management plan
DOE	U.S. Department of Energy
DOE-RL	U.S. Department of Energy-Richland Operations Office
DOI	U.S. Department of Interior
DQO	data quality objective
DST	double-shell tank
DW	dangerous waste
EE&T	environmental engineering and technology
EA	environmental assessment
Ecology	Washington State Department of Ecology
ECTS	environmental compliance tracking system
EDMC	Environmental Data Management Center
EII	environmental investigations instructions
EIS	environmental impact statement
EMI/MAG	electromagnetic induction/magnetometer
EMSL	Environmental Monitoring Support Laboratory
EPA	U.S. Environmental Protection Agency
ERDA	Energy Research and Development Administration
ERT	environmental response team
ESA	Endangered Species Act
FS	feasibility study

LIST OF ACRONYMS (cont.)

FSP	field sampling plan
FTS	financial tracking system
GC	gas chromatography
GEU	geotechnical engineering unit
GM	Geiger Mueller (gamma monitor probe)
GPR	ground-penetrating radar
HCN	hydrogen cyanide
HECR	Hanford environmental compliance report
HEHF	Hanford Environmental Health Foundation
HEIS	Hanford environmental information system
HGWDB	Hanford ground water database
HISS	Hanford inactive site survey
HMS	Hanford Meteorological Station
HP	Health Physics department (Westinghouse Hanford)
HPT	health physics technologist
HRS	hazard ranking system
HSO	health and safety officer
HSP	Health and Safety Plan
HSWA	Hazardous and Solid Waste Amendments (of 1984)
HSWMUR	Hanford site waste management units report
HWMA	Hazardous Waste Management Act
HMPD	Hanford multipurpose dosimeters
HWVP	Hanford Waste Vitrification Plant
IC	ion chromotography
ICRP	International Council of Radiation Protection
IM	interim measure
IRA	interim response actions
IRIS	integrated risk information system
IRM	Information Resources Management
IS&FP	industrial safety and fire protection
ISV	in situ vitrification
ITS	in-tank solidification
LAER	lowest achievable emission rate
LAP	laboratory analytical protocol
LLWPA	Low-Level Waste Policy Act of 1980
LLWPAA	Low-Level Waste Policy Amendment Act of 1985
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MCS	management control system
MDL	minimal detection limit
MHRS	modified hazard ranking system
MOU	memorandum of understanding
MSDS	material safety data sheet
msl	mean sea level
NCP	National oil and hazardous substances contingency plan
NCRP	National Council of Radiation Protection
NEPA	*National Environmental Policy Act*
NESHAPS	national emission standards for hazardous air pollutants
NIOSH	National Institute for Occupational Safety and Health

LIST OF ACRONYMS (cont.)

NOAA	National Oceanic and Atmospheric Administration
NOD	notice of deficiency
NORM	naturally occurring radioactive materials
NPDES	national pollutant discharge elimination system
NPL	national priorities list
NQA	nuclear quality assurance
NR	not reported
NRC	Nuclear Regulatory Commission
O&M	operation and maintenance
ORE	occupational radiation exposure
OSHA	*Occupational Safety and Health Act of 1970*
OSM	Office of Sample Management (Westinghouse Hanford)
OSWER	Office of Solid Waste and Emergency Response
OVA	organic vapor analyzer
PA/SI	preliminary assessment/site inspection
PARCC	precision, accuracy, representativeness, completeness, and comparability
PCB	polychlorinated biphenyl
PDMS	program data and management system
PEL	permissible exposure limit
PJSP	pre-job safety plan
PL	Public Law
PMP	Project Management Plan
PNL	Pacific Northwest Laboratory
PNRS	preliminary natural resource survey
PPE	personal protective equipment
PUREX	plutonium-uranium extraction (Plant)
QA	quality assurance
QAPI	quality assurance program index
QAPP	Quality Assurance Project Plan
QC	quality control
QCBSDB	quality control blind standards database
QI	quality instruction
QR	quality requirement
R&D	research and development
RA	risk assessment
RAD	radionuclides of concern
RAS	routine analytical services
RCR	review comment record
RCRA	*Resource Conservation and Recovery Act of 1976*
RCW	Revised Code of Washington (State)
RD	remedial design
RE	relative error
RFA	RCRA facility assessment
RfD	reference dose
RFI	RCRA facility investigation
RFI/CMS	RCRA facility investigation/corrective measures study
RI	remedial investigation
RI/FS	remedial investigation/feasibility study

LIST OF ACRONYMS (cont.)

RM	radiation monitor
RMCL	recommended maximum contaminant level
ROD	record of decision
RPP	RCRA past practice
RPT	radiation protection technologist
RSR	radiation shipping records
RWP	radiation work permit
SAP	Sampling and Analysis Plan
SARA	*Superfund Amendments and Reauthorization Act of 1986*
SAS	special analytical services
SC	site characterization
SCBA	self-contained breathing apparatus
SDWA	Safe Drinking Water Act
SITE	Superfund innovative technology evaluation
SOP	standard operating procedure
SOW	statement of work
SPS	sample preparation system
STEL	short-term exposure limit
SST	single-shell tank
SVS	semivolatile organic analysis
SWDA	Solid Waste Disposal Act
SWP	special work permit
TAG	technical assistance grant
TAL	target analyte list
TBC	to be considered
TBD	to be determined
TCL	target compound list
TLV	threshold limit value
TOC	total organic carbon
TRIS	training records information system
TS	physical analysis
TSCA	Toxic Substances Control Act
TSD	treatment, storage, and disposal
TWA	time-weighted average
UN	unplanned release not to an existing disposal facility
UPR	unplanned release to an existing disposal facility
USWB/USDA	U.S. Weather Bureau/U.S. Department of Agriculture
VOA	volatile organic analysis
VOC	volatile organic compounds
WA	Wilderness Act
WAC	Washington Administrative Code
Westinghouse Hanford	Westinghouse Hanford Company
WIDS	waste identification data system
WIMS	warehouse inventory management system
WPPSS	Washington Public Power Supply System
WRAP	waste receiving and processing
WSRA	Wild and Scenic Rivers Act

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WORK PLAN

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TABLES

1.0 INTRODUCTION

More than 1,500 waste sites have been identified on the Hanford Site. Most of the waste sites are located within one of four geographic areas on the Hanford Site that are referred to as the 100, 200, 300, and 1100 areas. Figure 1-1 shows the location of these areas. Each area has been placed on the National Priorities List (NPL) under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). The four areas have been subdivided into 21 waste area groups on the basis of type of facility and operation. For example, the 100 Area waste groups generally are equivalent to the inactive nuclear reactor sites. Each waste area group is further subdivided into operable units according to waste disposal practices, geology, hydrogeology, and other pertinent site characteristics. A total of 78 operable units have been identified. This process is continuing, and the total number of operable units, as well as the individual waste sites within each operable unit, are subject to change.

This work plan and the attached plans establish the objectives, procedures, tasks, and schedule for conducting a CERCLA remedial investigation/feasibility study (RI/FS) for the 100-KR-4 operable unit. The location of the 100-KR-4 operable unit is presented in Figure 1-2. All ground water, surface water, river sediment, and aquatic biota investigations for the entire 100-K Area will be carried out in accordance with the 100-KR-4 work plan. In addition, there are three source operable units within the 100-K Area. Source operable units include facilities that are potential sources of radiological or hazardous substance contamination. For example, the 100-KR-1 operable unit is considered a source operable unit because it contains a liquid waste disposal trench, a crib, an outfall structure, and retention basins. The scope for 100-KR-1 investigations include these sources, soils (surface and vadose zone), air, and terrestrial biota. The 100-KR-1 work plan is being prepared concurrently with this work plan. Work plans for the other two source operable units at the 100-K Area will be developed at a later date.

This work plan was developed in accordance with the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989) and the associated Action Plan. All work conducted under this work plan will conform to the conditions set forth in the agreement and consent order.

Pursuant to the consent order, relevant U.S. Environmental Protection Agency (EPA) guidance documents were consulted in the preparation of this work plan, including:

- *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA Interim Final* (EPA 1988a)
- *Data Quality Objectives for Remedial Response Activities* (EPA 1987)
- *Superfund Exposure Assessment Manual* (EPA 1988b)
- *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual* (EPA 1989a)

- *Risk Assessment Guidance for Superfund, Volume II, Environmental Evaluation Manual* (EPA 1989b).

1.1 PURPOSE AND SCOPE OF REMEDIAL INVESTIGATION/ FEASIBILITY STUDY

In the summer of 1988, EPA proposed that the 100 Areas at the U.S. Department of Energy (DOE) Hanford Site be included on the NPL (EPA 1988c). In anticipation of this proposal being finalized, the EPA, the Washington Department of Ecology (Ecology), and the DOE agreed on the division of the 100 Areas into operable units for the purpose of increasing the manageability of the site characterization and remediation processes (WHC 1989a). On October 4, 1989, the EPA issued its final ruling that included the placement of the 100 Areas on the NPL, effective November 3, 1989.

The purpose of collecting data in an RI/FS is clearly stated in the EPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 1988a):

> "The objective of the RI/FS process is not the unobtainable goal of removing all uncertainty, but rather to gather information sufficient to support an informed risk management decision regarding which remedy appears to be most appropriate for a given site."

The scope of the 100-KR-4 operable unit investigation includes ground water, surface water, river sediment, and aquatic biota. The ground water aspects of 100-KR-4 operable unit require a broader evaluation of surface sources than just 100-KR-1 operable unit. The amount of media-specific data needed to support the remedy selection process is dependent in part on the potential future use of the 100-K Area. This potential future use will determine the accessibility of humans and biota to the waste and contaminated media. Although the Hanford Site is owned by the federal government and set aside for DOE use, and institutional control is expected to be maintained in the future, an uncontrolled use scenario has been assumed for the development of RI data-gathering tasks.

Preliminary investigations of radiological contamination that resulted from past practices at the 100-K Area have been conducted by Dorian and Richards (1978). The information and findings of these studies have been used extensively in this work plan. Although a significant amount of data is available to describe certain site conditions, additional information is necessary to develop an acceptable understanding of the nature and extent of potential risks and to develop a suitable range of remedial action alternatives for the 100-KR-4 operable unit. Additional information is also necessary to substantiate existing data that may not be complete, currently evaluated, or validated.

1.2 PROJECT GOALS

The goals of the 100-KR-4 operable unit RI are to provide sufficient information to evaluate future use exposures in the risk assessment, and to develop and evaluate a range of remedial alternatives in the FS that could provide for continued restricted use or an unrestricted future use of the 100-K Area. The 100-KR-4 operable unit RI will be conducted in phases. However, sufficient data may be gathered in the initial phase so that subsequent RI work is not warranted. In addition, the RI will be implemented concurrently with the 100-KR-1 operable unit RI program, which will provide data that are required for the 100-KR-4 operable unit risk assessment and FS. Source operable units 100-KR-2 and 100-KR-3 may contain sources of ground water contamination. Therefore, the 100-KR-4 operable unit work plan will assess the need to investigate individual sources of ground water contamination from these operable units. The objective of this assessment is to evaluate each site as a potential candidate for an imminent and substantial endangerment or interim response action. The RI will include the following data-gathering goals:

- Identify the contaminants (radiologic and hazardous substances) that have been released or have potential to be released to the ground water, surface water, river sediment, and aquatic biota. (Releases to the unsaturated soil, air, and terrestrial biota will be addressed in the 100-KR-1 operable unit work plan.)
- Determine the nature and extent of contaminants in these media.
- Determine the distribution of contaminant concentrations in these media.
- Determine the direction and rate of migration of radiologic and hazardous substances in the ground water.
- Identify contaminant migration pathways and potential receptors.
- Identify the potential environmental impacts and risks to human health and the environment posed by radioactive and hazardous substances. In particular, identify imminent threats to human health and the environment during the initial phase of the RI.
- Compile the information necessary to develop and evaluate remedial alternatives and to select preferred remedial actions.

The goal of the 100-KR-4 operable unit FS is to evaluate potential remedial actions that encompass a range of appropriate waste management options by developing, screening, and analyzing remedial alternatives. The ultimate goal of the RI/FS is to allow the selection and subsequent implementation of a cost-effective remedial action plan that ensures the protection of public health and the environment. After public review of the RI and FS reports, DOE, EPA, and Ecology will select an appropriate remedy and document this choice in a record of decision (ROD). This will be followed by design, implementation, and monitoring of the chosen remedial action.

The RI/FS process (Figure 1-3) is divided into five phases: two RI phases (operable unit characterization and treatability investigation) and three FS phases (remedial alternatives development, screening, and analysis).

According to the Action Plan of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989), the following primary documents will be prepared and distributed for public review and comment: Phase II RI reports and Phase I, II, and III FS reports. The data collected during the initial RI phase provide the information needed to develop and evaluate remedial alternatives in the FS. The initial alternatives evaluation in the FS may, in turn, identify the need for additional data collection during the second phase of the RI.

1.3 ORGANIZATION OF WORK PLAN

The work plan is based on a knowledge of conditions at the 100-KR-4 operable unit that has been acquired from a review of the reference materials listed in Chapter 8.0, an area walkover of the operable unit by members of the work plan team, and conversations with former employees at the 100 Areas. The work plan will be modified and updated throughout the RI/FS process as additional information becomes available. In this manner, the work plan will provide efficient and effective directions consistent with project goals. A dynamic work plan will also serve to help document the rationale for project decisions and conclusions and thereby provide assistance in making subsequent remedial action decisions.

It is recognized that by the time this work plan is implemented, valuable data presumably will be available from RI/FS and Resource Conservation and Recovery Act of 1976 (RCRA) facility investigation/corrective measures study (RFI/CMS) projects at other 100 and 300 Area operable units.

Eight sections, including this introduction, are included in the work plan. Chapter 2.0 presents the history and current understanding of the waste generation, transfer, storage, and disposal processes and facilities within the 100-K Area that act as potential sources of contamination to 100-KR-4 operable unit. The environmental and physical setting of the 100-K Area and its surroundings are also summarized in Chapter 2.0.

Available data and potential contaminant exposure pathways are reviewed in Chapter 3.0 to develop a conceptual model for the operable unit. Waste sources, quantities, and characteristics are identified, along with the current understanding of the extent of contamination in the various environmental media. Federal and state standards, requirements, criteria, or limitations that may be considered as potentially applicable or relevant and appropriate requirements (ARAR) are identified, potential impacts to public health and the environment are assessed, and preliminary remedial action objectives are presented.

Chapter 4.0 summarizes what is known and, more importantly, what is not known, about the 100-KR-4 operable unit. By comparing the data needed to conduct an RI/FS with the data that are available now, the RI tasks can be defined.

Chapter 5.0 presents the activities necessary to conduct the two phases of the RI (operable unit characterization and treatability investigation) and the three phases of the FS (remedial alternatives development, screening, and analysis). Detailed activities for the treatability investigation are not described because such activities will depend on the information gathered during the site characterization phase of the RI and the results of the initial phases of the FS.

A project schedule is presented in Chapter 6.0. Modifications to the schedule may be made as new information is obtained before or during project implementation. The project management organization and responsibilities required to implement the RI/FS activities are discussed in Chapter 7.0. References used to develop the work plan are provided in Chapter 8.0.

Attachments include support documentation to be used in conjunction with this work plan and the other plans as necessary to manage, conduct, and control the RI/FS project:

- Attachment 1: Sampling and Analysis Plan (SAP) comprising
  Part 1 - Field Sampling Plan (FSP)
  Part 2 - Quality Assurance Project Plan (QAPP)
- Attachment 2: Health and Safety Plan (HSP)
- Attachment 3: Project Management Plan (PMP)
- Attachment 4: Data Management Plan (DMP)
- Attachment 5: Community Relations Plan (CRP).

Each of the plans is meant to be used in conjunction with the work plan and the other plans, thus minimizing duplication of information and description.

1.4 QUALITY ASSURANCE

The 100-KR-4 operable unit work plan and its attachments have been developed to meet specific EPA guidelines for format and structure, within the overall quality assurance (QA) program structure mandated by DOE-Richland Operations Office (DOE-RL) for all activities at the Hanford Site. The hierarchy of QA program documents applicable to this project follows:

- DOE-RL Order 5700.1A, *Quality Assurance* (DOE-RL 1983): This directive establishes broadly applicable QA program requirements, based on American Society of Mechanical Engineers (ASME) NQA-1, *Quality Assurance Program Requirements for Nuclear Facilities* (ASME 1989), for all projects conducted on the Hanford Site.
- Westinghouse Hanford *Quality Assurance Manual*, WHC-CM-4-2 (WHC 1989b): This document describes the program and procedures to be used to implement DOE-RL Order 5700.1A for all activities conducted by Westinghouse Hanford on the Hanford Site.

- The QA program plan for CERCLA RI/FS activities (WHC 1990a): This plan describes the means selected to implement WHC-CM-4-2 for CERCLA RI/FS environmental investigations, while accommodating the specific requirements for work plan format and content agreed on in the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989). The guidance contains a complete matrix of procedural resources (from WHC-CM-4-2 [WHC 1989b], from the Westinghouse Hanford *Environmental Investigations and Site Characterization Manual*, WHC-CM-7-7 [WHC 1989c], and from other sources) that may be drawn on to support lower-tier operable unit-specific project plans.

- 100-KR-4 QAPP: Included as Part 2 of the 100-KR-4 SAP, the QAPP supports the FSP. The QAPP defines the specific means that will be used to ensure that the sampling and analytical data obtained as part of the Phase I RI will be defensible and will effectively support the purposes of the investigation. As required for CERCLA RI/FS activities, the structure and content of the QAPP is based on *Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans* (EPA 1983). Where required, the QAPP invokes appropriate procedural controls from WHC-CM-7-7 (WHC 1989c) for CERCLA RI/FS activities or developed to accommodate the unique needs of this investigation.

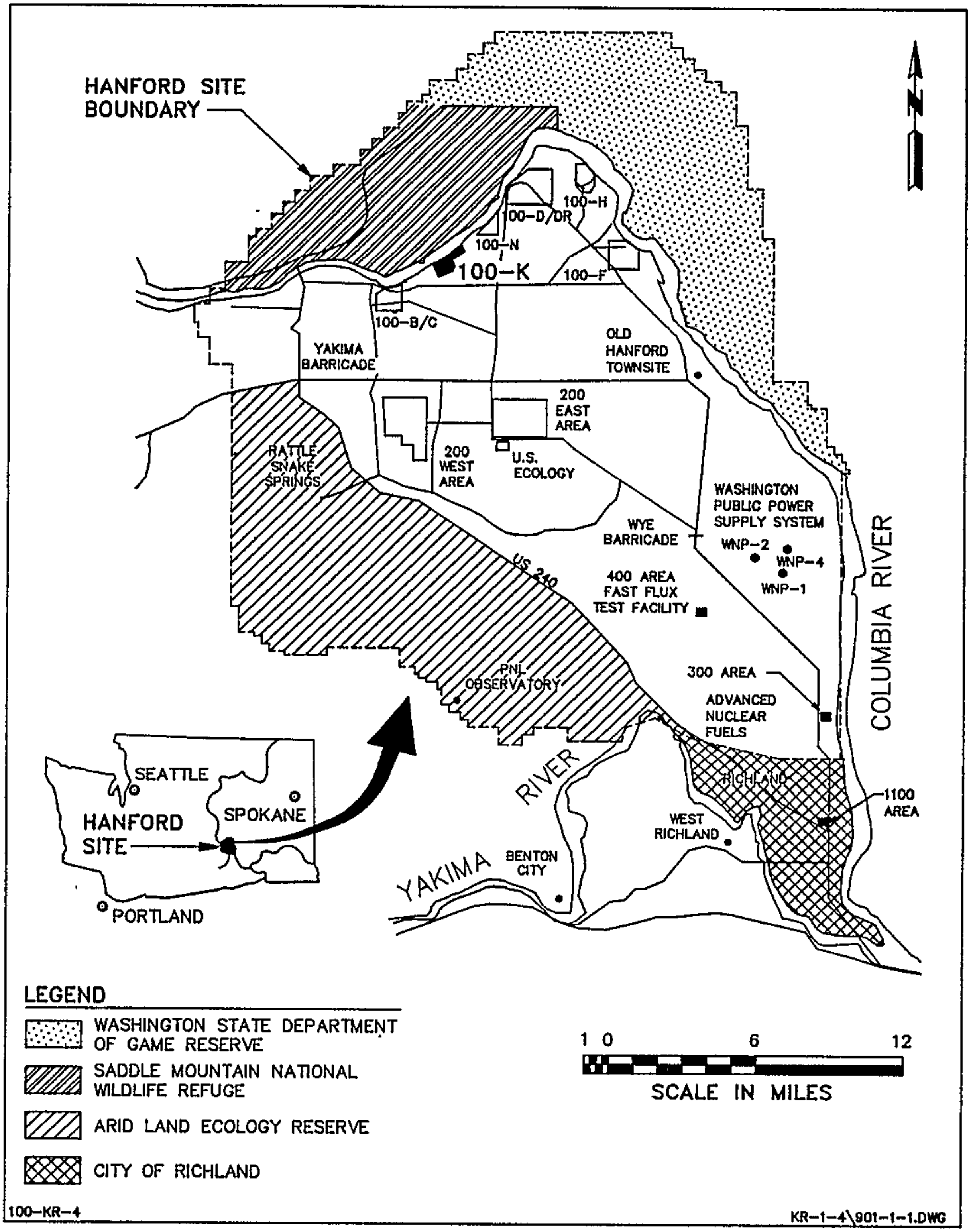

Figure 1-1. Hanford Site.

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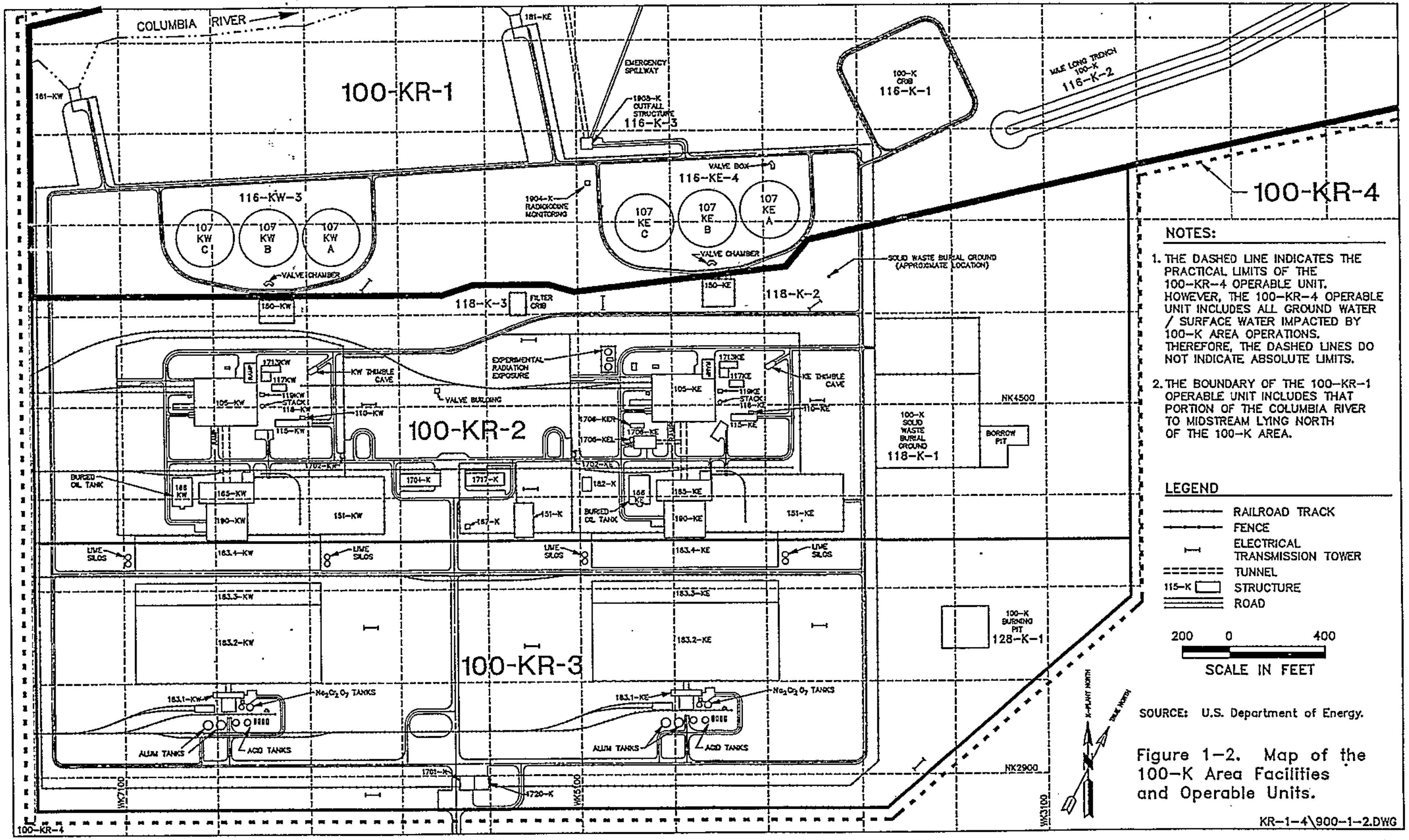

Figure 1-2. Map of the 100-K Area Facilities and Operable Units.

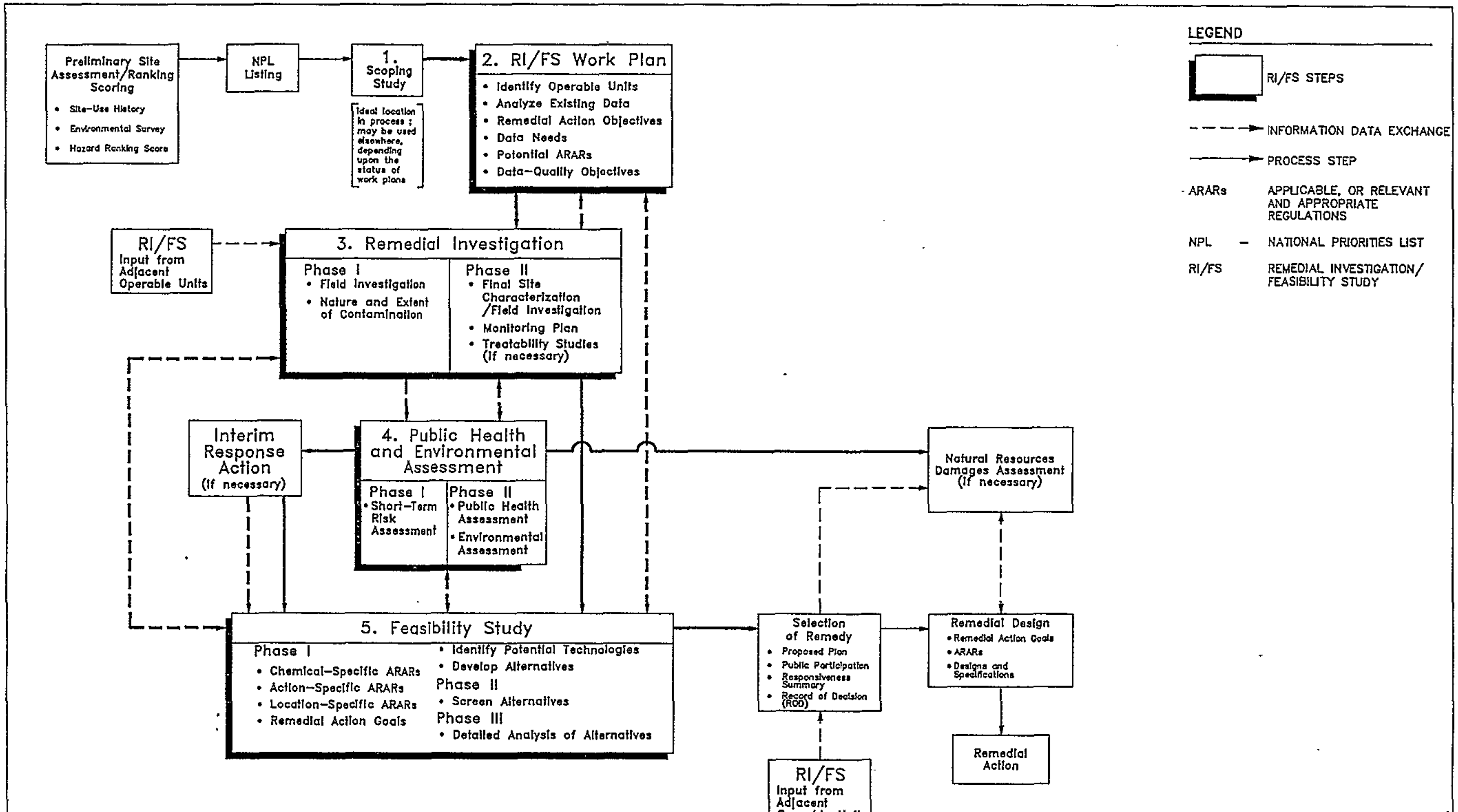

Figure 1-3. The RI/FS Process at Hanford.

2.0 OPERABLE UNIT BACKGROUND SETTING

This section presents a summary of the pertinent physical and historical setting for the 100-KR-4 operable unit.

2.1 OPERABLE UNIT SITE DESCRIPTION

2.1.1 Location

The Hanford Site is located in south central Washington state. The 100-K Area is located in the north central part of the Hanford Site, within Benton County, Washington, and is situated along the southern shoreline of the Columbia River (Figure 1-1). The area lies approximately 25 mi (40 km) northwest of the city of Richland, Washington. The 100-KR-4 operable unit encompasses all of the ground water, soils below the water table, and surface water of the 100-K Area and vicinity (Figure 2-1).

The operable unit covers an area of approximately 1.2 mi^2 (3.1 km^2) and is located within Sections 5 and 6 of Township 13 N, Range 26 E and Sections 31 and 32 of Township 14 N, Range 26 E and lies between Hanford grid south/north coordinates N36700 and N73500 and west/east coordinates W71700 and W63700, respectively. However, the 100-K Area was laid out on its own grid system, known as 100-K Area grid, which is rotated 27°09'59" counterclockwise from Hanford (true) north to the 100-K Area north. This system can be translated and rotated from the general Hanford grid using a coordinate transform equation.[1] The coordinate boundaries for the 100-K Area are approximately south/north coordinates N^K 2,900 and N^K 10,400 and east/west coordinates W^K (-)1,900 and W^K 7,600, respectively.

2.1.2 History of Operations

Between 1943 and 1963, nine water-cooled, graphite-moderated plutonium production reactors were built along the Columbia River upstream from the now-abandoned town of Hanford. Eight of these reactors (B, C, D, DR, F, H, KE, and KW) have been retired from service and are under evaluation for decommissioning. The ninth reactor (N Reactor) in the 100-N Area is currently on cold standby.

The KW and the KE reactors and support facilities were constructed between 1952 and 1954. The KW reactor operated from 1955 through 1970, when it was retired from service. The KE reactor operated from 1955 until 1971 and was then retired from service. Although a few ancillary structures were

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[1] $N^K = 0.8897\ N^H + 0.4566W^H - 94{,}331$
$W^K = -0.4566N^H + 0.8897W^H - 20{,}884$
where: N^K = North, K-Area coordinates
W^K = West, K-Area coordinates
N^H = North, Hanford coordinates
W^H = West, Hanford coordinates

shared by the reactor facilities, in general the major support operations were duplicated. Table 2-1 summarizes the history of 100-K Area operations.

Currently, there are several active facilities within the 100-K Area. They include the 105-KE and 105-KW fuel storage basins used to store spent fuel from the N reactor; the aluminum tanks adjacent to building 183.1-KE; research and development performed in 1706-KE; buildings used for site management; one pumphouse; one water treatment facility; and septic tanks and leach fields used for disposal of sanitary waste.

To minimize the potential spread of radioactive isotopes from the reactors and associated facilities, a plan for decontamination and deactivation of the reactors was implemented after reactor operations ceased. Deactivation generally consisted of removing equipment, electrical hardware, piping, and other items from the buildings and flushing or wiping pipes and equipment with decontamination agents.

2.1.3 Facility Identification

The facilities within the 100-K Area as they existed during active operations are shown in Figure 2-2 and listed in Table 2-2. The majority of the buildings remain standing. Buildings demolished or removed are noted in Table 2-2. The table includes the original facility identification number, facility name, years in service, purpose, and description (where known).

Two primary numbering systems have been used in the 100-K Area. Under the original Hanford numbering system, facilities were given a unique number (e.g., 105-KE for the KE reactor and 105-KW for the KW reactor). Most waste units were not assigned a unique number, but were instead referred to by the number of the nearby facility (e.g., 105-KE percolation french drain). The Waste Information Data System (WIDS) (WHC 1990b) was initiated in 1980 as an organized waste site identification system. The waste sites and some facilities were assigned waste site designation numbers (e.g., 116-KE-3 for the 105-KE percolation french drain) by WIDS. Throughout this plan, reference will be given to the site designation number.

2.1.4 Waste-Generating Processes

Wastes produced in the 100-K Area have been generated from the operation of the reactors and the support facilities. Waste streams potentially impacting the 100-KR-4 operable unit are (Stenner et al. 1988):

- Reactor process liquid wastes and cooling water effluent
- Miscellaneous radioactive liquid wastes
- Radioactive sludge/radioactive solid waste
- Sanitary liquid waste disposal
- Nonradioactive liquid waste disposal

- Nonradioactive solid waste disposal
- Herbicides to control vegetation.

2.1.4.1 Reactor Cooling Water System. The major component of liquid radioactive wastes generated in the 100-K Area resulted from the reactor cooling water circuits.

Reactor cooling water was pumped from the Columbia River. The water was treated and circulated in a single pass through each reactor. The cooling water exiting the reactor contained activation products from the reactor and also chemicals added during the water treatment process. Once through the reactor building, cooling water passed through a retention basin system and was then discharged to the river. At times, ruptured fuel elements contaminated the cooling water, which was then diverted to the 116-K-2 trench (Dorian and Richards 1978). Information regarding fuel cladding ruptures will be a part of the data compilation phase of this work plan. The cooling water circuit for the 100-K Area reactors is shown in Figure 2-3. The KE reactor cooling water system is described more fully in the following paragraphs. The KW reactor cooling water system is similar.

Columbia River water from the 181-KE river pumphouse was pumped to the water treatment facility in the 183-KE complex. At the 183-KE complex, the river water was treated with chemical additives to remove suspended matter and retard corrosion. These additives included aluminum and polyelectrolytes to enhance the removal of suspended solids by flocculation and filtration, respectively; sulfuric acid to control pH; and chlorine to control algae growth in the settling basins. The alum was produced by mixing sulfuric acid and bauxite. Commercially produced alum was stored southwest of the 183.1-KE treatment buildings as a backup. Concentrated sulfuric acid and bauxite were stored in steel tanks just outside the buildings. The chemical additives were introduced as the water passed down a flume into a mixing chamber (183.2-KE). From the chamber, the water traveled to a basin equipped with paddle wheel flocculators. After passing through the flocculators, the cooling water for the reactor then passed to one of six settling basins. Lime could be added at this point to adjust the pH of the system.

The water was then filtered through one of 12 rapid sand filters (183.3-KE). The filters were backwashed periodically, and backwash water from the filters was discharged to a process sewer. Before the advent of the National Pollutant Discharge Elimination System (NPDES) permit program, backwash water may have been discharged directly to the river, as indicated in the *1963 Hazards Summary Report*, (GE 1964; Figure III-1). Water exiting from the filters was piped to two subsurface 9,000,000 gal (3.4×10^7 L) clearwells (183.4-KE) for each reactor. Sodium dichromate was added to the clearwell discharge before it reached the coolant pump to inhibit corrosion of reactor piping.

The coolant pumps delivered the water to a distribution header in the 165-KE building, then to the reactor. Water that entered the reactor contained aluminum, chlorine, sodium dichromate, and residual impurities naturally present in river water that were not removed during treatment.

There were several flow paths through each reactor, the primary one being through the inside of 3,220 individual process tubes. A second pathway went through cooling pipes located in the thermal and biological shields. Other less voluminous flow paths through the reactors included circulation through the foundation and the horizontal control rods (20 per reactor) that penetrated the reactor core. The cooling water from all flow pathways was recombined before leaving the reactor building. Reportedly, cooling water flow through the reactor was about 200,000 gal/min (12,600 L/s).

Because of the thermal energy transfer from the reactor core, cooling water exited the reactor at a near-boiling temperature. The water passed through riser pipes on each side of the rear of the reactor, to a crossover pipe located above the reactor, and finally to a 'downcomer.' The water entering the downcomer cascaded downward through 30 rectangular flow channels, resulting in partial cooling. The water was discharged from the reactor building through cooling water effluent lines to the three 107-KE retention basins.

The 107-KE retention basins are three 9,000,000-gal (3.4×10^7-L), steel, open-air tanks used to cool the water and to let short-lived radioisotopes decay before release to the river. The basins originally operated on a cycle system whereby one basin would be filling with effluent, a second basin would be holding the effluent for cooling and short-lived radionuclide decay, and the third basin would be draining to either the river outfall or to the 116-K-1 crib for soil column percolation (in case of a fuel cladding failure). The cycling practice, however, was abandoned shortly after the 105-KE Reactor startup when this method of operation caused an outfall line to float and break. The outfall lines were anchored and the basin cycling system was then changed to send the coolant effluent to two basins in parallel. The third basin was usually empty and ready to receive fuel cladding failure effluent. Average retention time in the basins was approximately 1.5 h according to the *1963 Hazards Summary Report* (GE 1964).

Under normal operations, water from the retention basins was discharged through the 1908-K outfall structure to two 84-in. (213-cm) dia steel pipes discharging at the center bottom of the Columbia River. In the event that the discharge pipes became inoperable, the overflow from the outfall structure would have discharged directly onto the shore of the river through a concrete-lined emergency spillway. The emergency spillway was seldom used. During the years of reactor operation, there were frequent ruptures of the fuel cladding while fuel elements were in the process tubes. When this occurred, the cooling water effluent became significantly contaminated and was diverted to the 116-K-2 trench.

The 1904-K radioiodine monitoring building housed radioiodine monitoring devices that monitored radiation levels in KE and KW reactor cooling water being pumped between the 107-K retention basins and the 1908-K outfall structure. Increases in cooling water contamination would normally be noticed first in the reactor control room gamma monitors; the 1904-K monitors serving as additional, last-opportunity, effluent contaminant monitors. An alarm from the 1904-K monitors would normally result in reactor cooling water being redirected from the outfall structure to the 116-K-2 trench (to the 116-K-1 crib before its shutdown), or in other contaminant release minimization procedures.

2.1.4.2 Reactor Process Liquid Wastes and Cooling Water Effluent. The cooling water became irradiated while in the reactor by three mechanisms:

- The high neutron flux in the reactor activated elements in the cooling water and created radioisotopes such as ^{41}Ca, ^{51}Cr, and ^{65}Zn. Most of those radioisotopes are relatively short-lived and have since decayed to negligible levels, except for ^{41}Ca.

- Activation products from the piping, other reactor components, and fuel cladding were picked up by the cooling water. Significant radioisotopes included ^{3}H, ^{14}C, ^{60}Co, ^{63}Ni, ^{152}Eu, ^{154}Eu, and ^{155}Eu.

- Fuel element fission products such as ^{90}Sr and ^{137}Cs and transuranics such as $^{239/240}Pu$ were introduced into the cooling water during fuel cladding failures. Concentrations of radionuclides in the reactor cooling water were low during normal operations.

The contaminated effluent containing debris from a fuel cladding failure was diverted to a 4,100-ft (1,250-m) long trench, 116-K-2, which replaced the 116-K-1 crib in 1955. The 116-K-1 crib was reportedly used only once because it failed to percolate.

Discharges in addition to the contaminated effluent discharged into the 116-K-2 trench included retention basin leaks, which released cooling water to the area in and around the basins, lines, and flood plain at a rate as high as 10,000 to 20,000 gal/min (630 to 1,260 L/s). During reactor operations, evidence of water pooling on the ground adjacent to the retention basins was frequently noted (Dorian and Richards 1978). Effluent water in the basins also leaked through the valves into the lines that drained to the trench, causing the trench to fill and sometimes overflow. Information concerning leaks from the 107-KE and 107-KW retention basins will be developed during the data compilation phase of this project.

2.1.4.3 Miscellaneous Radioactive Liquid Wastes. There were several sources of radioactive liquid waste in addition to the reactor cooling water system. These miscellaneous wastes were disposed of to small cribs and drains as well as to the 116-K-2 trench by the reactor cooling water effluent piping. Examples of miscellaneous liquid radioactive wastes disposed to the ground include:

- Radioactive wastes generated by research and development activities (reactor loop studies) in the 1706-KE and 1706-KER buildings and disposed of to the 116-KE-2 trench

- Condensate and other waste from the 115-K reactor gas purification buildings disposed of to small volume cribs (116-KE-1 and 116-KW-1)

- An unknown volume of liquid that drained from the 105-KW and 105-KE basin floors into the 116-KW-2 and 116-KE-3 french drains, respectively.

Although undocumented, leakage may have occurred in several large underground oil storage tanks in 100-KR-2 and 100-KR-3 operable units because the 100-K Area was serviced exclusively by oil-fired power plants.

The 100-KR-2 operable unit also was the site for two ethylene glycol heat recovery systems (150-KE and 150-KW). There was one reported leak in these piping systems, occurring at the junction box next to the 150-KE parking lot.

Miscellaneous radioactive liquid wastes combined with reactor cooling water effluent include the following:

- Water from the hot water system, circulated through process tubes during reactor downtimes
- Cooling water system cleaning waste, consisting of a diatomaceous earth slurry used to scour the corrosive film from the reactor piping and tubes.

During reactor operation and shutdowns, large quantities of decontamination solutions were used routinely to remove radionuclides from facility equipment and surfaces. Known decontamination solutions included chromic, citric, oxalic, nitric, and sulfamic acids and fluoride. Reportedly, other chemicals, including organic solvents, were occasionally pumped through the cooling water effluent system. The majority of these decontaminant solutions were disposed of to the 116-K-2 trench.

2.1.4.4 Radioactive Sludge/Radioactive Solid Waste. Large volumes of radioactive sludge were generated during reactor operations and accumulated in the cooling water effluent system pipes, the 105-K fuel storage basins, the 107-K retention basins, and in water traps located in the 115-K gas treatment facilities. The 118-K-2 burial ground immediately to the east of the 107-KE retention basins was used to dispose of sludge removed from the 107-K retention basins. Reliable data has not been found regarding the disposal areas or the frequency, quantity, and characteristics of the sludge removed from each facility.

Sludges generally consisted of fine particulate matter that originated from dissolved and suspended solids in the river water, pipe slag, dust, failed fuel elements, and other undefined solids. The sludge was contaminated with radionuclides and various chemicals.

Radioactive solid wastes generated in the 100-K Area generally consisted of reactor components, contaminated equipment and tools, and miscellaneous contaminated items such as paper, rags, structural concrete, and similar matter. Reactor operations generated aluminum spacers, lead-cadmium, boron-carbide reactor poison pieces; boron splines; graphite; process tubes; lead gunbarrels, thimbles, control rods, nozzles, pigtails; and cadmium sheets.

Support facilities associated with the 100-K Area reactors generated additional radioactive solid wastes, such as air filters in the 115-K gas recirculation and 117-K exhaust air filter buildings, equipment used in connection with the cooling water effluent system, and contaminated sludge and dirt removed from effluent lines and valve pits. The primary burial ground (118-K-1) for 100-K Area solid wastes is in the 100-KR-2 operable unit.

2.1.4.5 Sanitary Liquid Waste Disposal. Sanitary liquid waste was disposed of to septic tank systems associated with structures in the 100-K Area. There were no known septic tank leaks within the 100-K Area, or documentation of the effects of septic tank effluent on 100-K Area ground water; however, the fact that the tanks have flowed to drainfields indicates a potential source of nonradioactive contamination in the ground water.

2.1.4.6 Nonradioactive Liquid Waste Disposal. Documentation of nonradioactive liquid waste disposal has focused on the chemicals associated with the water treatment facilities. In particular, sulfuric acid sludge from the four sulfuric acid storage tanks at each treatment facility was drained to french drains, percolation wells and percolation trenches, adjacent to the 183.1-K treatment buildings.

In 1971, about 12,000 lb (5,443 kg) of the sulfuric acid sludge were removed from the site. There are no known records of previous sulfuric acid sludge removals. Analysis indicated that about 14% of the sludge weight was composed of mercury as a byproduct of sulfuric acid production. There may be a significant amount of mercury remaining in the sulfuric acid sludge disposal facilities.

The 'crib' filter between the two sets of 107-K basins was used to dispose of nonradioactive process (demineralizer), and research and development waste from the 1706-KE building.

2.1.4.7 Nonradioactive Solid Waste Disposal. There is little documentation of the disposal of nonradioactive solid wastes. Burnable wastes were generally incinerated at the 100-K Area burn pit, east of the 183-KE water treatment plant. Large volumes of both construction and demolition wastes were disposed of at this site.

2.1.4.8 Herbicide Use. During a 1990 site visit to the 100-K Area, it was reported that herbicides had been used to control vegetation growth. According to past employees, herbicides were not used much during operating years because problem areas were remediated by scraping and adding topsoil. In the 1970s, herbicides and ground sterilants were used for both ground and aerial applications.

2.1.5 Decontamination and Deactivation

Although the area continues to be used, some of the 100-K Area facilities have undergone initial stages of decontamination and deactivation. The success of past facility decontamination and deactivation efforts has not been addressed in this work plan. However, such an evaluation will be part of the RI for the source operable units (100-KR-1, -2, and -3) and may, in the future, become an integral part of the RI/FS process.

After reactor shutdown in the early 1970s, efforts were undertaken to control airborne radioactivity and to protect wildlife and plants from contacting contaminants. Examples of these efforts included the following:

- Covering the bottom and sides of the northeast end of 116-K-2 trench to prevent access by wildlife

- Installing a 2-in. (5-cm) water line to supply water to the southwest end of 116-K-2 trench. The water supply was designed to keep the trench covered with water to prevent airborne transport of radionuclides. The 116-K-2 trench was subsequently backfilled to grade.
- Patching observable leaks in 107-K retention basins
- Installing various devices (whistles, vibrators, screens) in and near the 107-K retention basins to minimize attractive nuisance problems with wildlife
- Decontaminating 107-K retention basin walls and covering the floors with 2 ft (0.7 m) of dirt
- Covering of the bottom and sides of the 116-K-1 crib with dirt.

2.1.6 Interactions with Other Operable Units

As shown in Figure 1-2, the majority of the 100-KR-4 operable unit lies below the 100-KR-1, 100-KR-2 and 100-KR-3 operable units. In general, the waste sites and structures in 100-KR-1 are outside the actual operating facilities; 100-KR-2 contains reactor and reactor support facilities; and 100-KR-3 contains the water treatment activities. It should be noted that, because of the length of the 116-K-2 trench and resultant impact to ground and surface water, the 100-KR-4 operable unit extends more than 1 mi (1.6 km) downriver from the reactors.

The RI/FS activities are for 100-KR-1 and 100-KR-4 operable units. Where possible, activities will be coordinated to increase efficiency and cost effectiveness. Major RI/FS activities for the 100-KR-2 and 100-KR-3 units will be implemented later according to the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989). Information gained from the 100-KR-4 RI/FS work will benefit activities in adjacent units.

Although the work plans for 100-KR-2 and 100-KR-3 are not included in this document, it is important to note that all potential and significant sources of contamination are evaluated in the 100-KR-4 work plan, regardless of location. Significant sources were deemed to be those that rated high in *Hazard Ranking System Evaluation of CERCLA Inactive Waste Sites at Hanford* (Stenner et al. 1988) and *Test Methods for Evaluating Solid Waste* (EPA 1986).

2.1.7 Resource Conservation and Recovery Act Site Interactions

According to Appendix B of the action plan of the agreement (Ecology et al. 1989), the 100-K Area has a facility (1706-KE) that treats RCRA waste in a waste accumulation tank, an ion exchange column, a solidification unit (evaporator), and condensate tank. However, according to Appendix C of the action plan, none of the listed past-practice waste disposal units at the 100-K Area have been assigned corrective action authority under RCRA; they have been designated CERCLA past-practice units.

2.2 PHYSICAL SETTING

2.2.1 Topography

The 100-KR-4 operable unit is located southwest of the Columbia River under a gently sloping bench. This reach of the river is within the structural and topographic feature known as the Pasco Basin. The reactor units are 500 to 1,000 ft (150 to 300 m) from the Columbia River. Ground elevation at the site varies from 400 to 500 ft (120 to 150 m) above mean sea level. Topography of the 100-K Area and vicinity is shown on the water table map (Plate I).

The land surface slope averages 100 ft/mi (49 m/km) toward the northwest to the boundary of the 100-KR-1 operable unit. Just north of the 107-K retention basins, the slope of the land increases toward a river terrace that lies 10 to 15 ft (3 to 5 m) above the Columbia River. The average water surface elevations in this area is about 395 ft (120 m) above mean sea level (USGS 1986a). Topography of the 100-K Area and vicinity is shown on the water table map (Plate I).

2.2.2 Geology

This section discusses regional and site geology. The regional discussion covers the general geology of the Pasco Basin and Hanford Site. Site geology covers the 100-K Area and its immediate vicinity.

2.2.2.1 Regional Geology. The geology of the Pasco Basin has been studied extensively in recent years, primarily for the Basalt Waste Isolation Project and other facility siting studies (e.g., Liikala et al. 1988). A summary of this existing work (pertinent to the region of the 100 Areas) is presented in the following paragraphs.

2.2.2.1.1 Stratigraphy of the Hanford Site. The Hanford Site lies on the Columbia Plateau, which is a broad plain formed by the Miocene Columbia River Basalt Group between the Cascade Mountains (to the west) and the Rocky Mountains (to the east). In the central and western parts, the basalt is underlain predominantly by Tertiary continental sedimentary rocks and overlain by late Tertiary and Quaternary fluvial and glaciofluvial deposits. A generalized geologic cross section of the Hanford Site is shown in Figure 2-4 and summary of the stratigraphic units present in the Pasco Basin is shown in Figure 2-5. The principal geologic units beneath the Hanford Site are (in ascending order) the Columbia River Basalt Group, with interbeds of the Ellensburg Formation; the Ringold Formation; and the Hanford formation (informal designation). In some portions of the Hanford Site, a Plio-Pleistocene unit occurs between the Ringold and Hanford formations, but this unit is apparently absent north of the Gable Butte/Gable Mountain structure. Locally, Pleistocene/Holocene alluvium, colluvium, and eolian deposits veneer the surface.

2.2.2.1.2 Columbia River Basalt Group. The tholeiitic flood basalts of the Columbia River Basalt Group form the bedrock of the Pasco Basin. This thick sequence of basalt was formed between 6 and 17 million years ago, when large flows of lava erupted from fissures in the southeastern portion of the Columbia Plateau. The Columbia River Basalt Group is subdivided into four basalt formations, from oldest to youngest: Imnaha Basalt, Picture Gorge Basalt, Grande Ronde Basalt, and Saddle Mountains Basalt (Ledgerwood et al. 1978; Swanson et al. 1979). The Columbia River Basalt consist of more than 42,000 mi^3 (174,000 km^3) of basalt covering more than 64,000 mi^2 (166,000 km^2) (Tolan et al. 1987). Beneath the Pasco Basin, this basalt sequence may be as much as 14,000-ft (4,267-m) thick. Flows of the Columbia River Basalt Group are interbedded with and overlain by Miocene-Pliocene epiclastic and volcaniclastic sediments of the Ellensburg Formation (Swanson et al. 1979).

2.2.2.1.3 Ringold Formation. Following cessation of the Columbia River Basalt volcanism, sediments of the Ringold Formation accumulated in the Pasco Basin. The sediments were deposited between 8.5 and 3.7 million years ago in a fluvial/flood plain environment (Myers et al. 1979) to reach a thickness of more than 1,200 ft (366 m). The Ringold Formation overlies the Columbia River Basalt throughout most of the Hanford Site.

Within the Pasco Basin, the Ringold Formation has been classified into three stratigraphic section types (Tallman et al. 1981). The descriptions of these section types are summarized on Figure 2-6. Section type I, located throughout the central Pasco Basin, is subdivided into the following four textural units: (1) sand and gravel of the basal Ringold unit; (2) clay, silt, and fine sand with minor gravel lenses of the lower Ringold unit; (3) occasionally cemented sand and gravel of the middle Ringold unit; and (4) silt and fine sand of the upper Ringold unit (Tallman et al. 1981). Section type II consists of predominantly silt, sand, and clay with minor gravel lenses, and is north and east of Gable Mountain. Section type III is composed of talus, slope wash, and sidestream deposits that are along the flanks of anticlinal ridges and interfinger with the central basin deposits.

2.2.2.1.4 Hanford Formation. The Hanford formation (an informal geologic designation) lies unconformably on the eroded surface of the Ringold Formation, and locally, the basalt bedrock. The Hanford formation consists of cataclysmic flood sediments that were deposited when ice dams in western Montana and Idaho were breached, and massive volumes of water spilled abruptly across eastern and central Washington. The floods scoured the land surface, locally eroding the Ringold Formation, upper basalt flows, and interbeds. Thick sequences of sediments were deposited by several episodes of Pleistocene flooding, with the last major flood sequence dated about 12,000 yr ago (Fecht et al. 1985).

Cataclysmic flood deposits have locally been divided into two main facies, termed 'Pasco Gravels' facies and 'Touchet Beds' facies. The Pasco Gravels facies are composed of poorly sorted gravels and coarse sand indicative of a high-energy depositional environment. The Touchet Beds facies consist of rhythmically bedded sequences of graded silt, sand, and minor gravel units (Myers et al. 1979). These sediments are limited to areas where slack-water conditions existed.

2.2.2.1.5 Surficial Deposits. Eolian sediments, consisting of loess, active and inactive sand dunes, alluvium, and colluvium, locally veneer the surface of the Hanford Site.

2.2.2.1.6 Geologic Structure. The structural geology of the Pasco Basin is illustrated on Figure 2-7. The major structural feature of the region is a sub-parallel series of west- to northwest-trending folds known as the Yakima Fold Belt. Umtanum Ridge and Cold Creek Valley west of the Hanford Site are examples of structurally controlled anticlinal ridges and synclinal valleys. Gable Butte and Gable Mountain on the Hanford Site represent the eastward extension of the Umtanum Ridge structure (Fecht 1978, p. 17). More localized information indicates that the 100-K Area site lies in Wahluke syncline, a down-warped valley between the Gable Mountain and the Saddle Mountain anticlines. The orientation of this syncline and the elevations of the top of basalt near the 100-K Area are shown on Figure 2-8 (Myers et al. 1979).

2.2.2.2 Site Geology. The geologic setting underlying the 100-K Area is based on regional data for the Pasco Basin and the Hanford Site and preliminary interpretation of geologic information from wells drilled in and adjacent to the 100-K Area. Twenty-nine wells were drilled in the 100-K Area, nine wells were drilled in the adjacent 600 Area and one well was drilled in the 100-B/C Area. The locations of these wells are shown in Figure 2-9 (100-K Area and adjacent 600 Area) and Figure 2-10 (detail of 100-K Area). Construction information for these wells is summarized on Table 2-3.

Most of the 100-K Area wells penetrate only the uppermost portions of the geologic section, with all but five wells extending less than 100 ft (33 m) beneath ground surface. There are no drill holes in the 100-K Area that extend beyond 170 ft (56 m) below ground surface. Nearby wells in the 600 Area are likewise limited to the upper geologic section. The 600 Area comprises all of the Hanford Site outside of the 100, 200, 300, 400, and 1100 Area. One exception is well 699-81-62, which is completed in basalt at a depth of about 1,011 ft (308 m) below surface. (A handwritten note on the geologic log indicates it was deepened to 1,471 ft [748 m].) This well is located about 3,000 ft (915 m) east of the main portion of the 100-K Area. Another deep well, 199-B3-2, is located about 1.6 mi (2.6 km) southwest of the 100-K Area in the 100-B/C Area and is about 790 ft (240 m) deep. Information on the deeper subsurface conditions beneath the 100-K Area has been inferred primarily from these two wells. Figure 2-11 provides a graphic comparison between a centrally located 100-K Area well (199-K-10) and the two deep wells.

Well numbering conventions in the remainder of the report have been abbreviated. The full number for wells within the 100-K Area would be 199-K-#, which has been shortened to K-# or K# (e.g., 199-K-1 is referred to as K-1 [in some reports, the abbreviation 1-K-# also has been used]). The full numbers for the wells in the 600 Area around the 100-K Area have also been shortened (e.g., 6-78-72, rather than 699-78-72).

2.2.2.2.1 Site Stratigraphy. The geology in the 100-K Area consists of three principal formations of interest to this site investigation. From oldest to youngest, the site stratigraphy includes the Saddle Mountains Basalt of the Columbia River Basalt Group (intercalated with the Ellensburg Formation sediments), the Ringold Formation, and the Hanford formation. Surficial deposits include river sediments and fill. A conceptual geologic and hydrogeologic column for the 100-K Area is shown in Figure 2-12. This column is based on well logs for the 100-K Area and well 6-81-62. A geologic cross section, based on interpretation of the drillers' logs and notes, is presented in Figure 2-13. (The location of the cross section is shown on Figures 2-9 and 2-10.) This cross section addresses only the uppermost portions of the stratigraphic section (less than 200 ft [60 m] deep) because of database limitations. As mentioned previously, interpretation of the deeper stratigraphic units is based on information from two adjacent deep wells outside of the 100-K Area (wells 6-81-62 and 199-B3-2).

Saddle Mountains Basalt--The upper surface of the Saddle Mountains Basalt is expected to be approximately 525 ft (160 m) below ground surface. A contour map of the top of the Saddle Mountains Basalt is provided in Figure 2-8. The regional geologic setting suggests that the uppermost basalts are flows of the Elephant Mountain Member. Information from wells 6-81-62 and 199-B3-2 indicates the upper basalt will be about 100 ft (30 m) thick. Beneath these flows, the Rattlesnake Ridge sedimentary interbed of the Ellensburg Formation was encountered in the two deep wells. The interbed was logged in well 199-B3-2 as clay/sand/ash and as tuff/siltstone/sandstone/ conglomerate in Well 6-81-62. (Well 199-B3-2 apparently did not penetrate the entire interbed.) These sediments are expected to be about 40 ft (12 m) thick in the 100-K Area and overlie basalt flows of the Pomona Member.

Ringold Formation--The Ringold Formation beneath the 100-K Area is composed of interbedded fluvial deposits consisting of gravels, sands, silts, and clays and is probably a mixture of section type I and II described in Section 2.2.2.1.3. The Ringold Formation is not fully penetrated by wells in the 100-K Area. The two adjacent deep wells (199-B3-2 and 6-81-62) indicate that the thickness of the Ringold Formation is about 480 ft (145 m). This is based on the interpretation that the drillers' descriptions of cemented gravels and sands about 45 ft (15 m) below ground surface represent the upper Ringold contact.

The Ringold Formation is subdivided into the following three informal, site-specific units in the vicinity of the 100-K Area: Ringold unit 1, Ringold unit 2, and Ringold unit 3. The sediment sequences are differentiated based on lithologies. These designations are not to be confused with other Ringold Formation classifications elsewhere in the Pasco Basin such as the Upper, Middle, Lower, and Basal Ringold units of the type I facies of Tallman et al. (1981). The classification of Tallman et al. (1981) was developed principally for the Ringold Formation within the 200 Areas (south of Gable Mountain) and does not easily fit the Ringold Formation in the 100-K Area.

Ringold unit 3 is the deepest Ringold unit and is expected to consist predominantly of gravels and sands (possibly sandstone and conglomerate) based on information from wells 1-B3-2 and 6-81-62. The thickness of this unit is expected to be between 20 ft (7 m) and 65 ft (20 m).

Ringold unit 3 is overlain by Ringold unit 2, which consists of silts and clays with minor lenses of sands and gravels. It is approximately 360 ft (118 m) thick, and is made up of three subunits. The lowermost portion of unit 2 (Ringold unit 2c) is composed of a relatively thick section of clay, commonly referred to in drillers's logs as green or blue clay. The thickness of the blue clay is expected to be about 110 ft (36 m) in the 100-K Area. Overlying unit 2c is a more permeable sandstone or sandy siltstone (Ringold unit 2b). It is approximately 50 ft (16 m) thick. The uppermost portion of unit 2 is a light-colored clay layer, Ringold unit 2a. This layer may be continuous across the site and may be up to 200 ft (66 m) thick.

The Ringold unit 1 is characterized by alternating layers of consolidated and unconsolidated coarse sediments (sands and gravels). The consolidated soils are described in the drillers' logs and notes as caliche, cemented gravel, or gravel, sand and silt that drill slow and hard. The drillers' logs for wells K-10, K-11, K-27, K-28, K-30, 6-72-73, 6-73-61, 6-77-54, and 6-78-62 indicate zones of cemented sand and gravels. The uppermost cemented sand and gravels may be continuous across the site and may extend to Coyote Rapids, which have been mapped as Ringold Formation sediments and described as being associated with a "caliche" layer (Brown 1962). The thickness of the Ringold unit 1 sands and gravels is approximately 100 ft (30 m) at the 100-K Area.

Using the criteria that the top of the cemented gravels represents the contact between the Ringold and Hanford formations, the elevation of the top of the Ringold appears to range form about 369 to 462 ft (121 to 152 m) with the lowest elevation along the river.

Hanford Formation--The Hanford formation lies above the Ringold Formation and varies between 12 and 95 ft (4 to 31 m) in thickness. The variation in thickness depends largely upon topography with thinning of the formation toward the Columbia River. The contact with the Ringold Formation is unconformable and varies in elevation between well locations. The Hanford formation consists largely of unsorted gravel, sands, and boulders, which are typically unconsolidated.

Other Surficial Deposits--Adjacent to the Columbia River, recent alluvium is continually deposited and reworked. The magnitude of river flow and abundance of sediment ranging to boulders gives rise to a varied alluvial sequence.

Nearly the entire surface of the operable unit, with the exception of some locations along the steeply pitching river banks, has been disturbed by grading or excavation. Fill materials are largely composed of native materials. The extent of fill is greatest near the river bank terrace or at berms established adjacent to the 116-KE and KW retention basins, the 116-K-1 crib berm and local fill areas from washouts along the 116-K-2 trench. Comparisons of topographic maps from before and after reactor construction indicate that as much as 10 ft (3 m) of fill may have been placed underneath the retention basins. Recent information is provided by the Coyote Rapids 7.5-minute quadrangle map (USGS 1986b). Older information is from a topographic map numbered M-1600-K, Sheet 1, prepared by General Electric for the U.S. Atomic Energy Commission. One of the well logs (well K15) also indicates at least 10 ft (3 m) of casing had to be added to the top of the well casing before fill was brought into the area.

2.2.2.2.2 Site Structural Geology. Site-specific structural features cannot be identified from existing or current interpretations of the 100-K Area site geology. Interpretation based on regional features indicate that 100-K Area is situated on the northern limb of the Wahluke Syncline regionally described as gently dipping to the south (Figure 2-8).

2.2.3 Hydrogeology

A regional overview of the hydrogeology of the Hanford Site is presented in the first part of this section. This information provides a background setting for a more detailed discussion of the hydrogeology of the 100-K Area, which is included in the second part of this section.

2.2.3.1 Regional Hydrogeology. The Hanford Site lies near the center of the Pasco Basin, which is a sub-basin of the Columbia Basin. Ground water at the Hanford Site occurs under both unconfined and confined conditions.

The unconfined aquifer is contained primarily within sedimentary deposits of the Ringold and Hanford formations. The base of the unconfined aquifer is defined either by the clay zones of the lower Ringold Formation or by the top of Columbia River Basalts where the lower Ringold Formation is absent.

The depth to ground water beneath the central portion of the Hanford Site is generally 200 to 300 ft (61 to 91 m). However, north of Gable Mountain (in the 100 Areas) the water table is shallower (Liikala et al. 1988). A regional water table contour map of the unconfined aquifer is presented in Plate I. Ground water generally moves eastward across the Hanford Site toward the Columbia River, which receives ground water discharge from the unconfined aquifer along much of its length. The general eastward flow is interrupted by ground water mounds that occur near the 200 Areas as a result of artificial recharge from onsite disposal of cooling water. The unconfined aquifer is naturally recharged by precipitation, runoff from higher elevations, and influent reaches of the Yakima River and Columbia River. Most of the shallow ground water originating from natural recharge flows to the Hanford Site from the higher elevations along Rattlesnake Ridge down toward the Cold Creek and Dry Creek Valleys.

The Hanford Site lies within the regional discharge zone of the Pasco and Columbia Basins. The confined aquifers of the regional ground water flow system are contained in the interflow zones and in the associated sedimentary interbeds within the Columbia River Basalt Group. Intermediate or local confined systems may also occur in the Ringold Formation, where clay units act as aquitards.

2.2.3.2 Hydrogeology of the 100-K Area. As with the geologic information, site-specific hydrogeologic information for the 100-K Area has been developed based on information from 29 wells drilled within or immediately adjacent to the 100-K Area (K1 through K7, and K10 through K31). In addition, 10 other wells (K8, K9, 6-66-64, 6-70-68, 6-72-73, 6-73-61, 6-74-74, 6-78-62, 6-80-62, 6-81-62) are located in the 600 Area close enough to the 100-K Area to be of use in characterizing the 100-KR-4 operable unit. The locations and construction details of the wells relied upon for 100-KR-1 operable unit work plan are shown in Figures 2-9 and 2-10 and Table 2-3, respectively. Because numerous wells have been installed in and around the 100-K Area, efforts have been made to review and interpret the available data from the wells (if only in a qualitative sense) to provide the most efficient plan for additional work at the 100-K Area.

The history of well installation in the 100-K Area and vicinity is summarized in Table 2-4. Lithologic data from boring logs are available for nearly all 100-K Area wells. Hydrologic information, such as water level measurements and aquifer test data, is limited but is sufficient for preliminary definition of hydrostratigraphic units and ground water flow directions beneath the 100-K Area. Where site-specific information is not available, reference has been made to information available from other sites. In particular, all but one of the wells in the 100-K Area and immediate vicinity are shallow, i.e., penetrate only the upper portion of the unconfined aquifer.

Ground water information is also available from surveys of springs along the shoreline of the Columbia River. There are an estimated 14 springs along the river bank assigned to the 100-K Area reach of the Columbia River (McCormack and Carlile 1984). The locations of the springs are shown in Figure 2-14 and the spring characteristics are described in Table 2-5.

2.2.3.2.1 The 100-K Area Hydrostratigraphy. The conceptual hydrostratigraphic column for the 100-K Area is shown in Figure 2-12. Comparison of the hydrostratigraphic and stratigraphic units is provided by this figure. The hydrostratigraphic interpretation for the 100-K Area is based on available borehole logs as compared with known regional conditions. Because of the greater potential impact of the waste sites on shallow ground water, the hydrostratigraphic units are discussed in descending order starting from ground surface. The layer designation (A, B, and C) of the various layers have been provided for clarity and are not related to other nomenclature used to describe the Hanford Site hydrostratigraphy.

The available borehole logs, most of which were prepared by the drillers, generally lack detailed geologic description or classification of the subsurface material encountered. However, the logs correlate with general descriptions of the typical lithologic section for the Hanford Site. Several of the wells were installed by the same drillers, who made detailed notes; therefore, the logs are consistent and useful. In addition, the drillers frequently noted depth(s) of water occurrences and provided qualitative assessments of the water occurrence (such as gain, loss, or sufficient water for drilling). Based on this information, there appear to be higher permeability zones that correlate with lithologic variations, indicating potential variations in lateral and vertical ground water (and contaminant) movement.

The hydraulic characteristics presented below are based primarily on Hanford Site conditions (regional information) because only limited information is available specifically for the 100-K Area. However, the reported ranges of values give an idea of the relative permeabilities of the hydrostratigraphic units. Conditions within the 100-K Area are expected to be within the reported ranges because of stratigraphic similarities between the 100-K Area and the Hanford Site region.

Vadose Zone--Several different stratigraphic units occur within the vadose zone, including fill, loess, alluvium, the Hanford formation, and the Ringold Formation. Because the water table occurs within the uppermost cemented gravel underneath much of the Hanford Site (which has been interpreted as the upper portion of the Ringold Formation), the unsaturated portion of the Ringold Formation has also been included in the vadose zone.

The thickness of the vadose zone varies from about 30 to 75 ft (10 to 25 m) across the 100-K Area because of topographic variations. The vadose zone may have been reduced in thickness historically because of ground water mounding during site operations.

Water contents at depth in vadose zone sediments at the Hanford Site are generally low, ranging from 2 to 7% by weight in coarse-grained soils and 7 to 15% in silts (Gee and Heller 1985). Measurements of matrix potential (i.e., the energy required to extract water from a soil against the capillary and adsorptive forces of the soil matrix) at depths greater than 30 ft (9 m) suggest that water in the deeper sediments is slowly draining to the water table (Hseih et al. 1973).

Ringold Producing Layer A (Ringold Unit 1)--Ringold producing layer A consists of the saturated sediments of Ringold unit 1. These sediments include layers of sand and gravel with some cemented zones. A cemented zone, up to 30 ft (10 m) thick, is present across the water table in the central portion of the 100-K Area (around wells K-10 and K-29); it is not known if this layer is continuous across the 100-K Area. The continuity of the cemented zones and the degree of cementation may effect ground water flow and contaminant transport.

The potential effect of the cemented sand and gravel layers on contaminant movement is evident in the variations in cation exchange capacities (CEC). Available CEC data are summarized in Table 2-6, along with the lithologic descriptions of the samples. Significant increases in CEC values, which could indicate decreased contaminant mobility, correspond to layers in which caliche or clay were noted. Note that other wells have cemented zones but have no CEC data.

Ringold producing layer A is about 95 ft (31 m) thick. Hydraulic conductivities of similar materials on the Hanford Site range from 20 to 6,000 ft/d (6.9×10^{-5} to 2×10^{-2} m/s) (Table 2-7).

Confining Layer B (Ringold Unit 2a)--At the three deeper Ringold well locations in the 100-K Area (wells K1, K11, and 6-78-62), a light-colored layer variously described as clay, shale, ash with silt, sand, and gravel was encountered. The drillers noted a significant reduction in water production in this layer. None of the three wells fully penetrates the layer. At about the same depth in well 6-81-62, a lighter colored siltstone layer about 40 ft (12 m) thick was encountered. Because of the significantly reduced production capacity of this layer, it has been considered to have a potential impact on ground water and contaminant movement by restricting vertical migration.

Confined Aquifer B (Ringold Unit 2b)--None of the 100-K Area wells was drilled into this layer. This layer is assumed to consist of sandstone or sandy siltstone between confining layers B and C, and to have a thickness of about 50 ft (15 m). Based on variations in lithology encountered in well 6-81-62, there are probably alternating producing and confining layers corresponding to alternating lithologies within this zone. Hydraulic conductivities of similar materials on the Hanford Site range from 0.11 to 10 ft/d (3×10^{-7} to 3.5×10^{-5} m/s) (Table 2-7).

Confining Layer C (Ringold Unit 2c)--The lowermost portion of Ringold unit 2, which was logged as blue clay at well 199-B3-2 and as green or dark grey to black and medium-siltstone and claystone at well 6-81-62, is the confining layer above Ringold unit 3. The thicknesses of this unit at wells 199-B3-2 and 6-81-62 are about 140 ft (43 m) and 105 ft (32 m), respectively. It is assumed that a similar layer exists beneath the 100-K Area.

Confined Aquifer C (Ringold Unit 3)--The thickness of this unit is approximately 60 ft (20 m) at well 199-B3-2 and about 25 ft (8 m) at well 6-81-62. In well 199-B3-2 it was logged as clay, sand, and gravel; in well 6-81-62, it was logged as sandstone and conglomerate. As with confining layer C, it is assumed that a layer similar to Ringold sequence exists beneath the 100-K Area. The hydraulic conductivities for this unit reportedly range from 0.01 to 1,000 ft/d (4×10^{-8} to 4×10^{-3} m/s) (Table 2-7).

Basalt Aquitard (Elephant Mountain Basalt)--Detailed information about the uppermost basalt encountered in wells 199-B3-2 and 6-81-62 is currently not available. The occurrence of flow tops, flow interiors, vesicular zones, or other features has not yet been determined. However, in both wells 199-B3-2 and 6-81-62, the thickness of the uppermost basalt layer is at least 100 ft (30 m); therefore, it is expected to impede vertical ground water movement beneath the 100-K Area.

Although the uppermost portion of this basalt may be a more permeable flow top, it is assumed that a less permeable flow interior is also present in this section, acting as an aquitard. Reported hydraulic conductivities for flow tops in the Saddle Mountains Basalt range from 10^{-2} to 10^{3} ft/d (10^{-8} to 10^{-3} m/s; Strait and Mercer 1987). LaSala and Doty (1971) estimated effective porosity of various zones of the Columbia River Basalts. They list a value of 10% for fractured basalt zones, but no estimates were made specifically for Saddle Mountains Basalt flow tops. No data are available for review for flow interiors in the Saddle Mountains Basalt, but flow interiors in the Wanapum and Grand Ronde Basalts have hydraulic conductivities ranging from 10^{-9} to 10^{-3} ft/d (10^{-15} to 10^{-9} m/s; Strait and Mercer 1987). The reported effective porosity for the flow interior is less than 1% (DOE-RL 1982). Only one hydraulic conductivity value is reported specifically for the Elephant Mountain Basalt (2,040 ft/d [7×10^{-3} m/s]); however, this is probably representative of a more permeable zone in the basalt (Gephart et al. 1979).

Basalt Interbed Aquifer (Rattlesnake Ridge Interbed)--The uppermost interbed encountered in wells 199-B3-2 and 6-81-62 was logged as clay/sand/ash and welded tuff/siltstone/sandstone/conglomerate, respectively. It was apparently not completely penetrated in well 199-B3-2 but was about 40 ft (12 m) thick in well 6-81-62.

Reported hydraulic conductivities for the interbeds in the Saddle Mountains Basalt range from 10^{-7} to 10^{-2} ft/d (10^{-13} to 10^{-8} m/s) with a storativity of 10^{-3} to 10^{-4}. The reported effective porosity for interbeds in general is less than 10% (DOE-RL 1982). Reported mean hydraulic conductivities specifically for the Rattlesnake Ridge Interbed range from 0.1 to 100 ft/d (4×10^{-3} to 4 m/s) (Table 2-7) (Gephart et al. 1979).

2.2.3.2.2 Ground Water Flow. The water table elevation varies from about 385 to 400 ft (117 to 122 m) above mean sea level based on 1989 measurements in and around the 100-KR-4 operable unit. A contour map of the ground water elevations is shown on Figure 2-15, along with the individual well measurements. The gradient is relatively flat, on the order of 0.0009 to 0.004, and is steeper near the Columbia River, as a result of either lithologic variations affecting transmissivity or the influence of the Columbia River elevation with time. The overall gradient is toward the Columbia River, as would be expected from regional conditions, but also shows a downriver influence.

It is expected that the water levels in the wells closest to the Columbia River fluctuate on the order of several feet in conjunction with fluctuations in river levels near the 100-K Area. Changes in the Columbia River level near the 100 Area can be attributed to fluctuation in flow through the upriver Priest Rapids Dam. In the 100-H Area, fluctuations of approximately 10 ft (3.0 m) in the Columbia River level result in fluctuations of about 2 ft (0.6 m) in the water level in a well approximately 1,000 ft (300 m) from the Columbia River, as shown on Figure 2-16. A similar condition is assumed to exist in the 100-K Area. The flow gradient will change in response to river levels and may periodically reverse near the river. The river effect may be even greater in the 100-K Area, as compared to the 100-H Area, based on the relative orientations of the areas with respect to the river system, local lithology, and width of the river channel.

The changes in the ground water levels as a function of time may have affected ground water quality in the 100-K Area and in surrounding areas. For example, at the eastern end of the 116-K-2 trench, which is near the 100-N Area, ground water may periodically flow toward the 100-N Area (and vice versa), depending on the relative sizes of ground water mounds beneath the 100-K and 100-N areas. When the mound beneath the 100-K Area was large, it may have driven contaminants toward the east and northeast.

Ground water flow directions and rates in the deeper confined aquifers may be different than in the unconfined aquifer. For example, in the uppermost basalt aquifer, the flow direction may be to the south-southeast (Gephart et al. 1979, Graham et al. 1984).

2.2.3.2.3 Ground Water Recharge and Discharge. Recharge and other inflow to the shallow ground water system beneath the 100-K Area may include the fluctuating water level of the Columbia River; percolation of precipitation, upward leakage of ground water from the deeper confined aquifers and lateral flow of unconfined ground water. The system discharges through similar mechanisms (e.g., discharge to the river and evaporation, for example).

Ground Water/Surface Water Exchange--Ground water in the unconfined aquifer in the 100 Area discharges to the Columbia River. Water from cribs and trenches in the production areas increased the volume of this flow. During times of high-river stage, the gradient may temporarily reverse near the Columbia River, causing water to flow from the river into the sediments.

Precipitation--The amount of recharge from precipitation varies at different locations on the Hanford Site, depending on rainfall intensity and distribution, vegetative cover, soil texture, subsurface layering, and depth to ground water. Kirkham and Gee (1984) estimate that recharge is 1 to 3 in/yr (2.5 to 7.6 cm/yr) for grass-covered soils. In areas covered with deep-rooted plants, little or no recharge occurs (Gee et al. 1989; Routson et al. 1988).

Upward Leakage--The potential for upward leakage of ground water from deeper confined aquifers exists, because the potentiometric surface elevation is generally higher than the water table elevation (Gephart et al. 1979). However, the quantity of such leakage, if any, has apparently not yet been determined in the 100 Area, and its impact is poorly understood.

Lateral Flow and Site Discharges--Lateral ground water flow is from the south under natural conditions. However, the presence of a ground water mound underneath the 100-K Area during reactor operation may have locally overridden the natural gradient. Intentional and unintentional release of production water to facilities including septic tanks, cribs, ditches, ponds, and leaking retention basins apparently created mounding beneath the 100-K Area site.

2.2.3.2.4 Historic Effects of 100-K Area Operations. Comparison between the water table elevations in 1967 and 1989 provides a partial understanding of the differences in ground water conditions before and after reactor operations. During the operation, a ground water mound existed as shown by the 1967 data (Figure 2-17). This mound locally elevated the water table as much as 25 ft (8 m) above the 1989 conditions. This increased elevation probably had several effects including reducing water table fluctuation from Columbia River elevation changes. Of greater concern is the increased potential for downward contaminant migration, as a result of the opportunity for contaminated water recharging the water table coupled with increased hydraulic heads, and lateral migration in almost all directions away from the 100-K Area. Once production ceased, the ground water elevations reverted to 'natural' conditions.

Figure 2-18 shows water level measurements in three representative wells as a function of time and illustrates the rapid reduction in the water table elevation once production ceased. These data are also listed in Table 2-8. Well 6-72-73, which is farther from the 100-K Area reactors and the associated cooling tanks (about 1 mi [1.6 km] southwest), showed the least change. Well K11, within the 100-K Area but slightly upgradient of the reactors, showed greater change. However, the greatest changes were in well K20, which is downgradient of the reactors and along the 116-K-2 trench through which cooling water was discharged.

2.2.4 Surface Hydrology

The following section provides information on 100-K Area drainage patterns and also discusses stream flow and flooding potential of the adjacent Columbia River.

2.2.4.1 Site Drainage Patterns. No well-defined drainage channels exist within the 100-K Area because of the relatively flat topographic surface and highly permeable surficial deposits in the area. There is evidence of erosion between the north fence of the 100-K Area and the Columbia River. Surface runoff from the 100-K Area could reach the Columbia River during significant storm events.

2.2.4.2 Springs. During times of low water, springs have been observed along the stretch of the Columbia River adjacent to the 100-K Area (McCormack and Carlile 1984) (Figure 2-14). The seepage consists primarily of bank storage draining back into the Columbia River. The volume of spring discharges at the 100-K Area has not been quantified.

2.2.4.3 Stream Flow Characteristics. The Columbia River flows through the northern edge of the Hanford Site and forms part of the Hanford Site's eastern boundary. The Columbia River is regulated by 11 dams within the United States, 7 upstream and 4 downstream of the Hanford Site as shown in Figure 2-19. The nearest upstream impoundment is Priest Rapids Dam and the nearest downstream impoundment is McNary Dam.

The Hanford Reach of the Columbia River is a free-flowing stretch of river extending from the Priest Rapids Dam to the head of Lake Wallula, which is created by McNary Dam. Flows typically range from 36,000 to 250,000 ft^3/s (1,000 to 7,000 m^3/s) and during peak spring runoff, flows up to 450,000 ft^3/s (12,700 m^3/s) have been recorded (McGavock et al. 1987). Monthly mean flows typically peak from April through June and are lowest from September through October. Maximum river depths range from 10 to 40 ft (3 to 12 m) at normal flow rates in the vicinity of the 100-K Area. Daily river elevations may fluctuate up to 5 ft (21.6 m) because of hourly water releases from Priest Rapids Dam (ERDA 1975). The monthly average river temperatures range from approximately 3°C in February to 19°C in August. There are numerous bends and several islands throughout the Hanford Reach.

There are three important time scales with regard to flow volumes in the Columbia River. There are daily variations associated with power production at Priest Rapids Dam and weekly variations associated with power production that reflect business cycle needs. In addition, there are seasonal variations associated with highly regulated discharges of the upper Columbia River to meet irrigation, flood control, and fishery conservation goals.

2.2.4.4 Flooding Potential. Historical records note that the maximum Columbia River floods occurred in June 1894 and June 1948 with maximum flows of approximately 740,000 and 690,000 ft^3/s (21,000 and 19,500 m^3/s), respectively (McGavock et al. 1987). The likelihood of floods with recurring magnitude has been significantly reduced since 1948 by construction of several flood control, water storage, and electric power-generation dams upstream of the Hanford Site. The probable maximum flood, a theoretical maximum flood resulting from the most severe combination of meteorologic and hydrologic conditions possible in the region, would produce an approximate peak flow of 1,400,000 ft^3/s (39,600 m^3/s). A flood of this magnitude would be expected to inundate much of the 100-K Area (Cushing 1988), as shown in Figure 2-20. The 100- and 500-yr floods would have a lower flow magnitude than the probable maximum flood and are not expected to significantly affect the area.

The potential impact resulting from a hypothetical 50% breach of the Grand Coulee Dam has also been evaluated by the U.S. Army Corps of Engineers. The discharge resulting from the breach at the outfall of the dam was determined to be 8,000,000 ft^3/s (226,500 m^3/s) (Cushing 1988), which would flood the 100 Areas, 300 Areas, and most of Richland, Washington, as shown in Figure 2-21.

2.2.5 Meteorology

Climatological data are available from the Hanford Meteorological Station (HMS) located between the 200 East and 200 West areas in the central portion of the Hanford Site. Since 1945 data have been collected at the HMS, located approximately 7 mi (11 km) south of the 100-K Area. Climatological data from the HMS are assumed to be representative of conditions at the 100-K Area. Additionally, wind data have been collected at 13 other sites on the Hanford Telemetry Network. The precipitation, temperature, wind, and evapotranspiration summaries presented in the following sections were largely extracted from DOE (1987).

2.2.5.1 Precipitation. The Hanford Site is located within a rain shadow formed by the Cascade Mountains 80 mi (130 km) to the west. The area is considered a desert, with an average annual precipitation of 6.3 in. (16 cm). Most of the precipitation falls during the winter, with nearly half of the annual amount occurring from November through February. Average winter monthly snowfall ranges from 0.3 in. (0.8 cm) in March to 5.3 in. (13.5 cm) in January. The record snowfall of 24 in. (62 cm) occurred in February 1916, but the second highest recorded snowfall was less than half this amount.

Days with precipitation greater than 0.5 in. (1.3 cm) occur with a frequency of less than 1% during the year. Rainfall intensities of 0.5 in/h (1.3 cm/h) persisting for 1 h are expected once every 10 yr. Rainfall intensities of 1.0 in/h (2.5 cm/h) for 1 h are expected only once every 500 yr.

The average annual relative humidity is 54%. Humidity is higher in winter than in summer, averaging about 75% and 35%, respectively.

2.2.5.2 Temperature. Average monthly temperatures at the Hanford Site range from 29°F (-1.5°C) in January to 76°F (24.7°C) in July. The lowest recorded monthly average winter temperature was 21°F (-5.9°C), and the highest recorded monthly average winter temperature was 44°F (6.9°C); both of these records were set during February. The highest recorded monthly average summer temperature was 82°F (27.7°C), which occurred during July. The coolest summer month on record was in June at 63°F (17.2°C).

2.2.5.3 Wind. Wind roses for 14 locations on the Hanford Site are displayed in Figure 2-22. The 100-K Area lies approximately equidistant from Hanford Telemetry Network Stations 13 and the HMS. The wind roses show prevailing winds from the northwest, with a secondary maximum for southwesterly winds. Winds from the northwest quadrant occur most often during winter and summer. During spring and fall, the frequency of southwesterly winds increases whereas winds blowing from other directions display minimal seasonal variation.

Monthly low average wind speeds are 6.2 to 6.8 mi/h (10 to 11 km/h). Monthly peak wind speeds average 8.7 to 9.9 mi/h (14 to 16 km/h) in the summer. Winds are usually southwesterly and in the summer, the high-speed southwest winds are responsible for most of the region's dust storms. In addition, high-speed winds are associated with afternoon winds and thunderstorms. The summertime drainage winds are normally northwesterly with average wind speeds up to 31 mi/h (50 km/h). An average of 10 thunderstorms occur annually, but the winds do not display a directional preference.

2.2.5.4 Evapotranspiration. Mean annual evapotranspiration for the area immediately southeast of the Hanford Site has been estimated to be about 29 in. (74 cm).

2.2.6 Environmental Resources

2.2.6.1 Flora. The 100-K Area consists of undeveloped semiarid land with clusters of industrial buildings connected by a surface network of roadways, railroads, and electrical transmission lines. A significant amount of the active flora in the 100-K Area has been disturbed as a result of construction, reactor operation, and deactivation activities. Vegetation is controlled in contamination zones using nonselective herbicides. The natural vegetation consists mostly of a sparse covering of desert shrubs and drought-resistant grasses. The predominant vegetation type is the sagebrush/cheatgrass/bluegrass community, and bitterbrush and rabbitbrush are also common shrubs (DOE 1987; Jaquish and Mitchell 1988). A narrow riparian zone, consisting of grasses and herbs interspersed with a few scattered deciduous shrubs and trees, exists along the banks of the Columbia River.

Table 2-9 includes state-designated endangered and threatened flora that potentially exist at the Hanford Site. State designations are as strict as or stricter than federal designations. The endangered persistent sepal yellowcress, generally found in moist to marshy places, is known to inhabit the Hanford Reach shoreline of the Columbia River. Therefore, this endangered species could appear along the river shoreline of the 100-K Area.

Several threatened plant species are located within or near the Hanford Site. Eatonella is known to occur along the Columbia River in nearby Grant County and could, therefore, occur along the Columbia River in or near the 100-K Area. The Columbia River milk-vetch is locally endemic near the vicinity of Priest Rapids Dam. It is unlikely that this species would be encountered near the 100-K Area. Hoover's desert parsley is known to exist in Benton County, but appears to inhabit only rocky hillsides and is thus unlikely to occur at the 100-K Area.

2.2.6.2 Fauna. The predominant fauna of the sagebrush/grass community that potentially reside in or near the 100-K Area are the cottontail rabbit, jackrabbit, Great Basin pocket mouse, horned lark, and the western meadowlark. Mule deer, elk, coyotes, and various species of raptors forage in this habitat type. Grasshoppers are the most conspicuous insects in the community (DOE 1987).

Dominant fauna along the Columbia River include muskrat, porcupine, raccoon, quail, pheasant, and waterfowl (ducks and geese) (DOE 1987). The long-billed curlew is also known to nest within the cheatgrass habitat in the 100-K Area (Allen 1980). A spit on the south side of the island at the tip of the peninsula between the 100-D/DR and 100-H Areas and about 5 mi (8 km) downstream from the 100-K Area serves as the primary loafing and staging area for curlews from the Hanford Site and the Wahluke Slope (Allen 1980). Peak waterfowl use occurs from late December through mid-January. Great Basin Canadian geese have historically nested on the sparsely vegetated islands in the Hanford Reach of the Columbia River. A resident flock of Canadian geese nests on islands in the Columbia River near 100-D/DR Area about 5 mi (8 km) downstream from the 100-K Area (Fitzner and Rickard 1975). Goose nests established on these islands have been counted each year since 1953 during the nesting season. The results have varied each year with a general upward trend occurring in recent years as shown in Figure 2-23. The shift may be attributable to the increase in coyote population in the upstream islands (Jaquish and Bryce 1989).

The Columbia River provides habitat for a wide variety of fish. Important game species are chinook salmon, steelhead, coho salmon, sockeye salmon, smallmouth bass, largemouth bass, sturgeon, walleye, yellow perch, and channel catfish. The Hanford Reach provides the most important area in the main stem of the Columbia River for fall-spawning chinook salmon. Increases in this population over the years are responsible for attracting numerous bald eagles to the area in the fall and winter to feed on the spawned-out salmon carcasses (Jaquish and Bryce 1989) as shown in Figure 2-23.

Table 2-10 also lists state endangered and threatened fauna that could appear at the Hanford Site. The American white pelican and the Aleutian Canadian goose are endangered animal species that occasionally occur on and along the Columbia River near the 100-K Area. During 1989, the population of white pelicans along the Hanford Reach of the river increased from a transient population of only 7 to 12 birds to more than 50.

The bald eagle and ferruginous hawk, threatened species, are frequent visitors to the Hanford Site. Bald eagles spend the winter months along the Hanford Reach of the Columbia River and use groves of tall trees along the Columbia River as a roosting site. Ferruginous hawks nesting pairs have been counted on the Hanford Site since 1977. The trend toward population increases is attributed to the hawks' attraction to recently constructed electrical transmission line towers as nesting sites (Jaquish and Bryce 1989).

2.2.6.3 Critical Habitats. The roost trees and foraging areas of the bald eagle and ferruginous hawks may be regarded as critical habitats and should, therefore, be protected (Department of Wildlife 1987). Because the other endangered and threatened animal species that use the 100-K Area environment are transient by nature, no critical animal habitats have been declared in that area.

If the endangered persistent sepal yellowcress or the threatened eatonella are found to exist within or near the 100-KR-1 operable unit, the area where they exist would constitute a critical habitat for such plants. No specific information concerning the existence of these species within the project boundaries is currently available.

2.2.6.4 Land Use. Access to the Hanford Site is administratively controlled and is expected to remain so for the foreseeable future to ensure public health and safety and for reasons of national security (DOE 1987). The Hanford Site is currently zoned as an unclassified use district by Benton County. Under the county's comprehensive land-use plan, the Hanford Site may be used for nuclear-related activities. Nonnuclear activities are authorized only on approval from DOE (DOE-RL 1989).

Immediately north and across the Columbia River from the 100 Area is the Saddle Mountain National Wildlife Refuge and the Department of Wildlife Reserve (Figure 1-1). These lands provide a buffer zone around the reactor complexes (DOE 1987).

Land use in the area surrounding the Hanford Site consists primarily of irrigated and dry-land farming, livestock grazing, and urban and industrial development. Agricultural lands are found north and east of the Columbia River and south of the Yakima River. Principal agricultural crops include hay, wheat, potatoes, corn, apples, soft fruit, hops, grapes, and vegetables. Most industrial activities in the area are associated with either agriculture or energy production (DOE 1987).

2.2.6.5 Water Use. The 100-K Area has two NPDES discharges (outfalls) under Permit No. WA-000374-3. These outfalls are designated 003 (which is the 181-KE inlet screen backwash) and 004 (which is the 1908-K effluent discharge outfall). This permit is being renegotiated with the EPA. The following measurements are required for the nonradioactive 100-K discharges: flow rate, suspended solids, temperature, pH, and chlorine.

The nearest known domestic use ground water well is located about 6 mi (10 km) upstream from the 100-K Area at the Vernita Bridge. Because of the surrounding land use, the closest private well that could be located to the 100-K Area would be approximately 4 mi (6 km) to the north across the Columbia River.

2.2.6.6 Sensitive Environments. The Columbia River's importance as a recreational resource and a regional source of drinking and irrigation water, as well as being a productive habitat for waterfowl, economically important fish species, and transitory endangered and threatened wildlife, could merit special concern for the environment during implementation of remedial activities at the 100-K Area. Because of the presence of critical bald eagle habitat (Section 2.2.6.3), the 100-K Area and vicinity could be regarded as a sensitive environment, as defined in 40 CFR Part 300, Appendix A.

The Columbia River is regarded as an important environment with respect to the 100-K Area. The Hanford Reach has been designated a class A (excellent) surface water by Washington Administrative (WAC) WAC 173-201-080(2). This designation requires that water quality be maintained for the following uses:

- Domestic, industrial, and agricultural water supply
- Stock watering
- Fish and shellfish migration, rearing, spawning, and harvesting
- Wildlife habitat
- Recreation (including primary contact recreation)
- Commerce and navigation.

The Hanford Reach is also being considered for status as a national wild and scenic river (Jaquish and Bryce 1989).

2.2.7 Human Resources

The following sections discuss demography, archaeological and historical resources, and community involvement.

2.2.7.1 Demography. No one resides on the Hanford Site. Land use in the area precludes any residential unit being closer than 5 mi (8 km) to the 100-K Area. The working population for the entire 100 Area is not a constant, but ranges between 500 and 1,000.

2.2.7.2 Archaeological Resources. Archaeological sites are found in various locations on the Hanford Site, several along the Hanford Reach of the Columbia River. Many of the Hanford historic sites are listed in the National Register of Historic Places in Archaeological Districts. The Ryegrass Archaeological District overlaps the 100-K Area operable units and includes three archaeological sites. Two of the sites (45BN149 and 45BN151) are camp sites; the third is a cemetery (site 45BN150) used from prehistory into recent times (Rice 1980). In addition to its National Register listing, this site is considered to be sacred by the Wanapum and Yakima Indian people. Upstream of the 100-K Area is the proposed Coyote Rapids Archaeological District. Consisting of sites 45GR312, 45GR313, 45GR314, and 45BN152, this district was nominated to the National Register, but rejected for lack of information (Cushing 1988). Additional archaeological resources may exist along the Columbia River immediately adjacent to the 100-K Area, in areas that have not been surveyed for cultural resources.

2.2.7.3 Historical Resources. The Coyote Rapids, located immediately upstream of the 100-K Area, is the site of two historically important properties. During the 1850s, events took place at a camp on the Columbia River's south bank near Coyote Rapids that were of great significance to the Northwest Indian people. It was here that Smohalla, prophet of the Wanapum people, held the first *washat* or dance ceremony of what is now referred to as the Dreamer or Seven Drums religion (Relander 1956). As a result of Smohala's personal abilities, the religion spread to many neighboring tribes, and is now practiced by members of the Colville, Nez Perce, Umatilla, Warm Springs, and Yakima tribes. The place where this event is thought to have occurred is archaeological site 45BN152.

The second event was the development of irrigation in the Hanford area. In the early twentieth century, a business consortium from Seattle, Washington, constructed an electrical plant at Priest Rapids and a pumping station just above Coyote Rapids to supply water to the Hanford Ditch. Without this development, the towns of White Bluffs and Hanford would not have prospered. The irrigation system is now represented by the pumping plant known as the Allard Pumping Plant and by segments of the Hanford Ditch.

2.2.7.4 Community Involvement. The involvement of the potentially affected community with respect to the RI/FS for the 100-KR-4 operable unit is described in the CRP (Attachment 5) that has been developed for the Hanford Site Environmental Restoration Program. The CRP includes a discussion and analysis of key community concerns and perceptions regarding the project, along with a list of all interested parties.

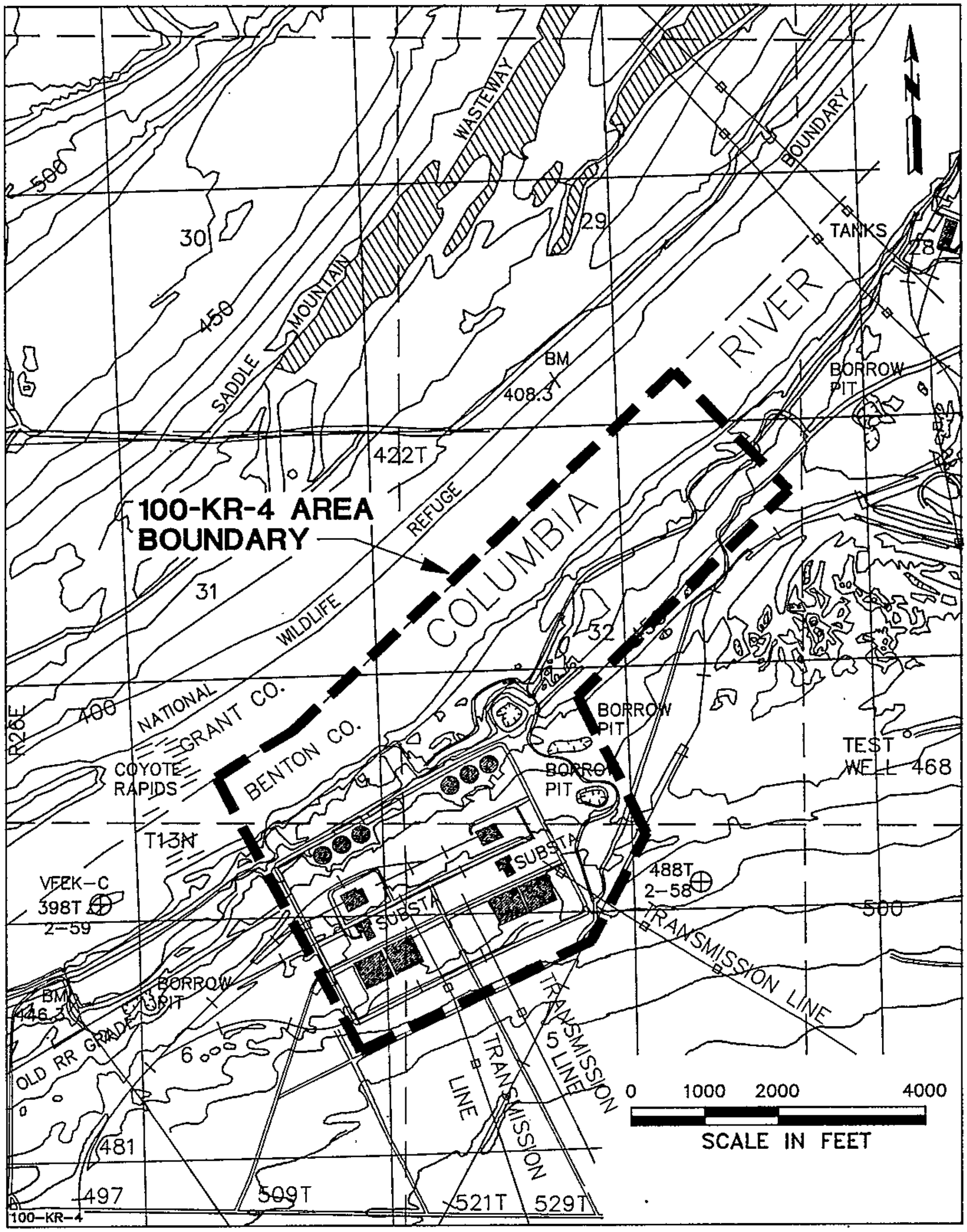

Figure 2-1. Location Map of the 100-KR-4 Operable Unit.

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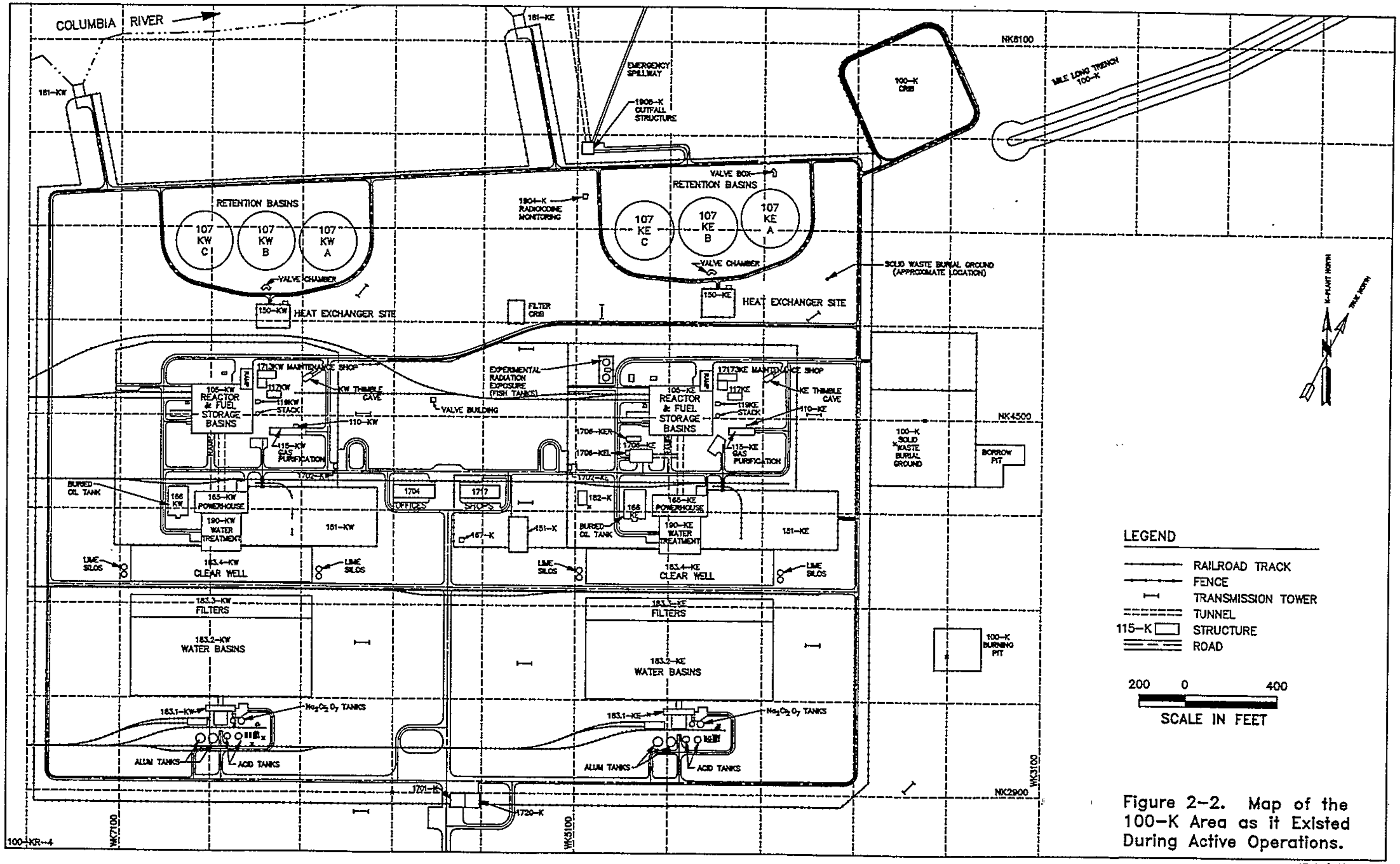

Figure 2-2. Map of the 100-K Area as it Existed During Active Operations.

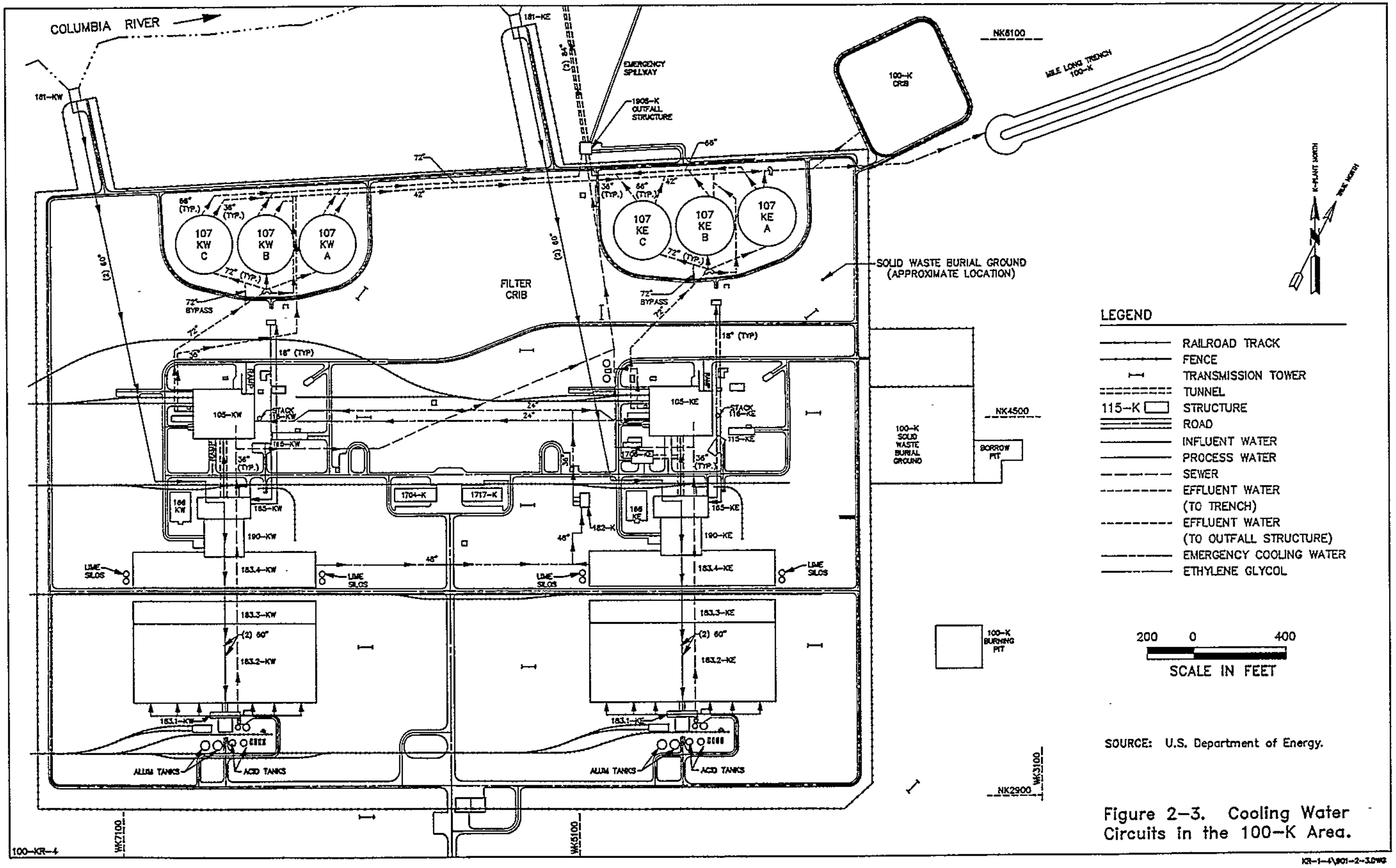

Figure 2-3. Cooling Water Circuits in the 100-K Area.

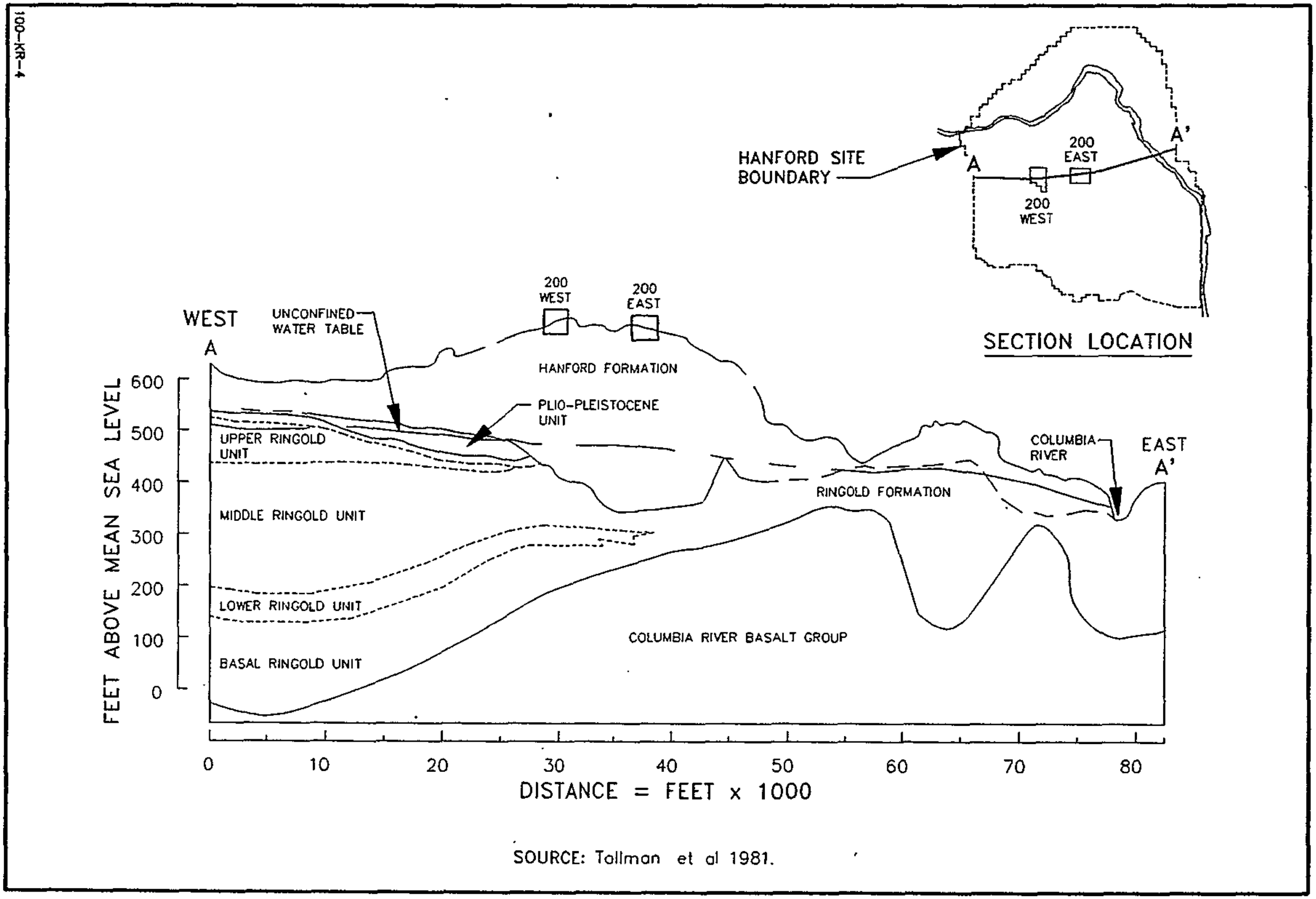

Figure 2-4. Generalized Geologic Cross Section of the Hanford Site.

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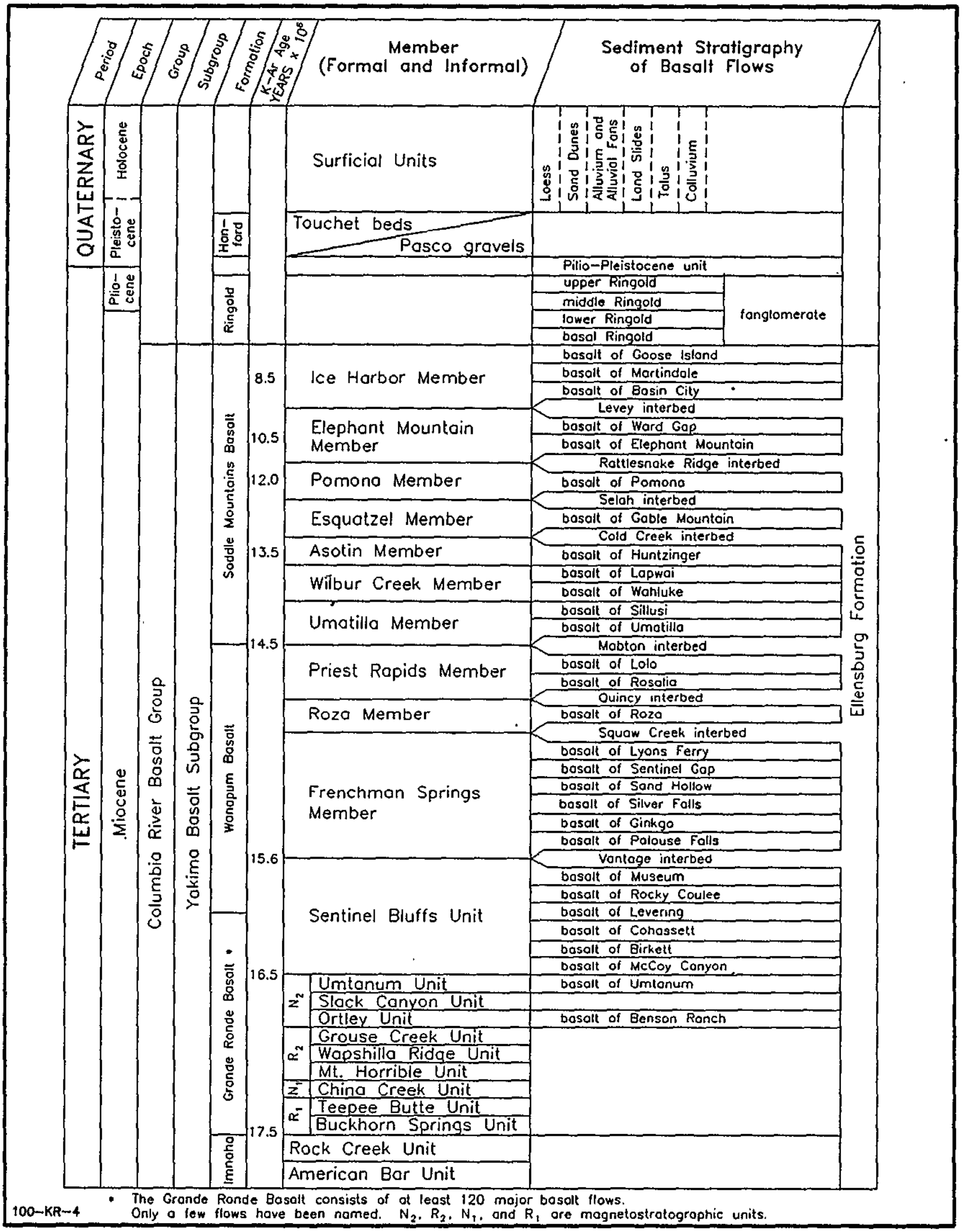

Figure 2-5. Summary of Stratigraphic Units in the Pasco Basin.

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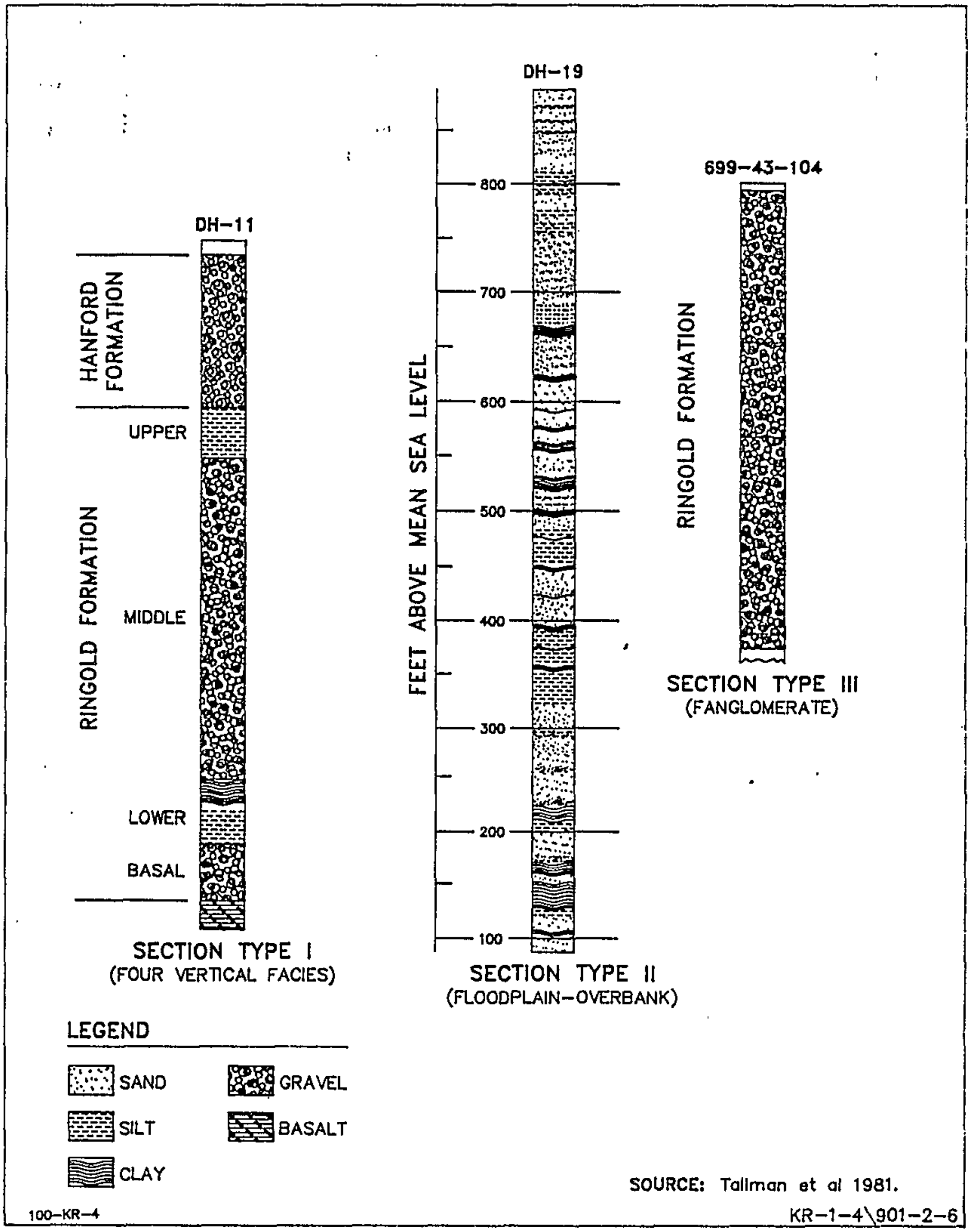

Figure 2-6. Ringold-Type Facies at the Hanford Site and Vicinity (after Tallman et al. 1981).

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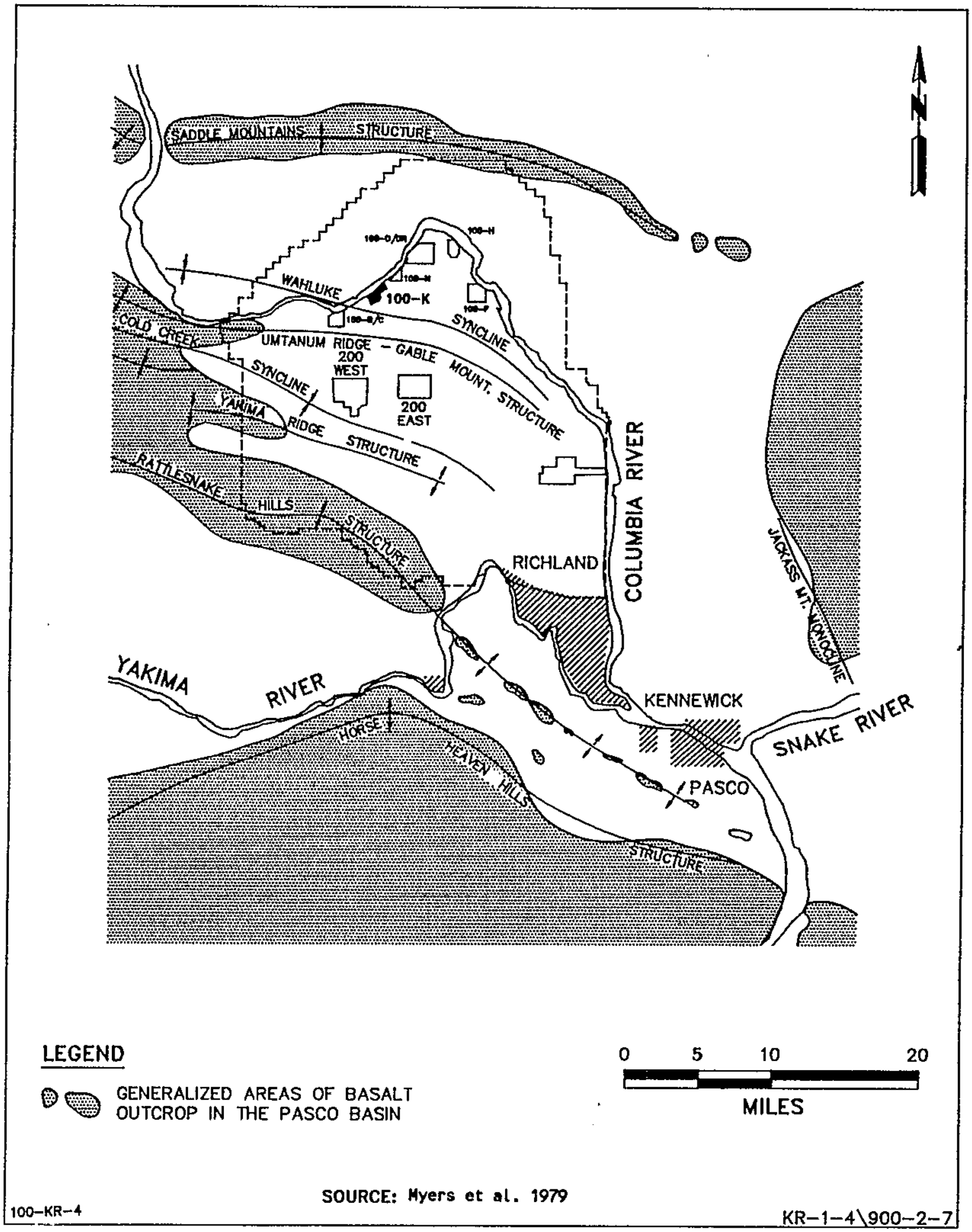

Figure 2-7. Structural Geology of the Pasco Basin.

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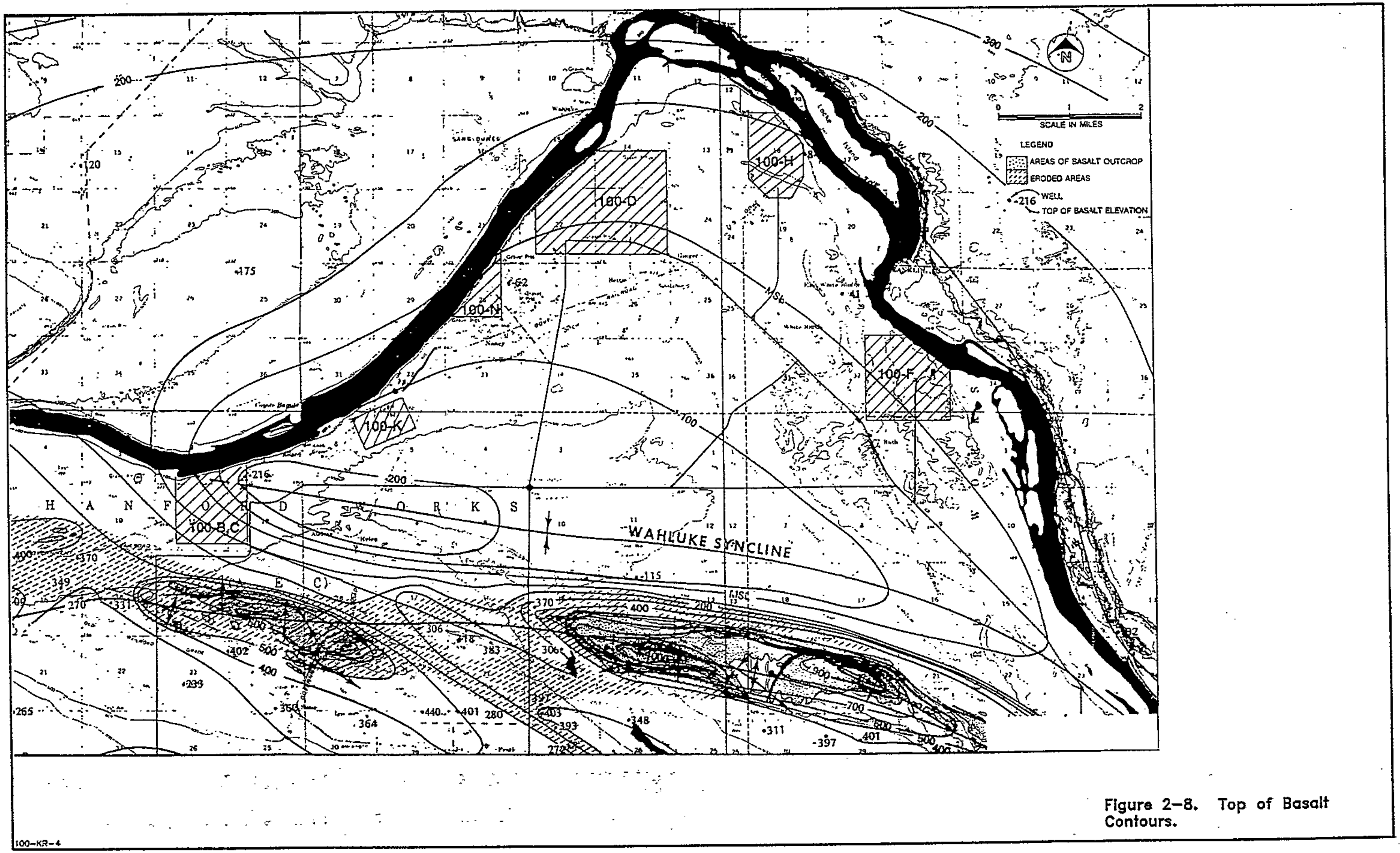
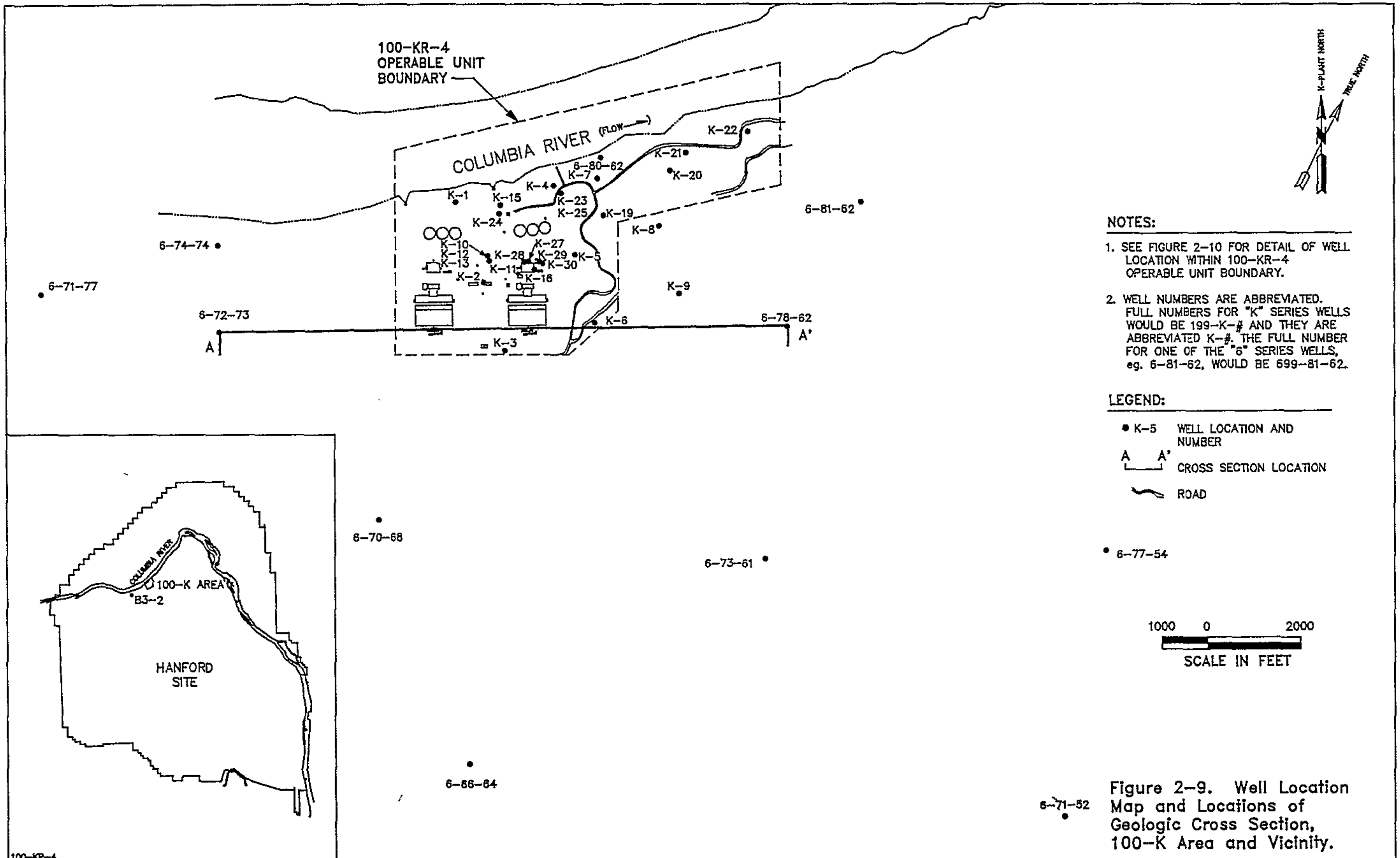


Figure 2-8. Top of Basalt Contours.

9 1 1 2 1 7 0 1 3 0 5



NOTES:

1. SEE FIGURE 2-10 FOR DETAIL OF WELL LOCATION WITHIN 100-KR-4 OPERABLE UNIT BOUNDARY.
2. WELL NUMBERS ARE ABBREVIATED. FULL NUMBERS FOR "K" SERIES WELLS WOULD BE 199-K-# AND THEY ARE ABBREVIATED K-#. THE FULL NUMBER FOR ONE OF THE "6" SERIES WELLS, eg. 6-81-62, WOULD BE 699-81-62.

LEGEND:

● K-5 WELL LOCATION AND NUMBER

A A' CROSS SECTION LOCATION

ROAD

Figure 2-9. Well Location Map and Locations of Geologic Cross Section, 100-K Area and Vicinity.

KR-1-4\901-2-9.DWG

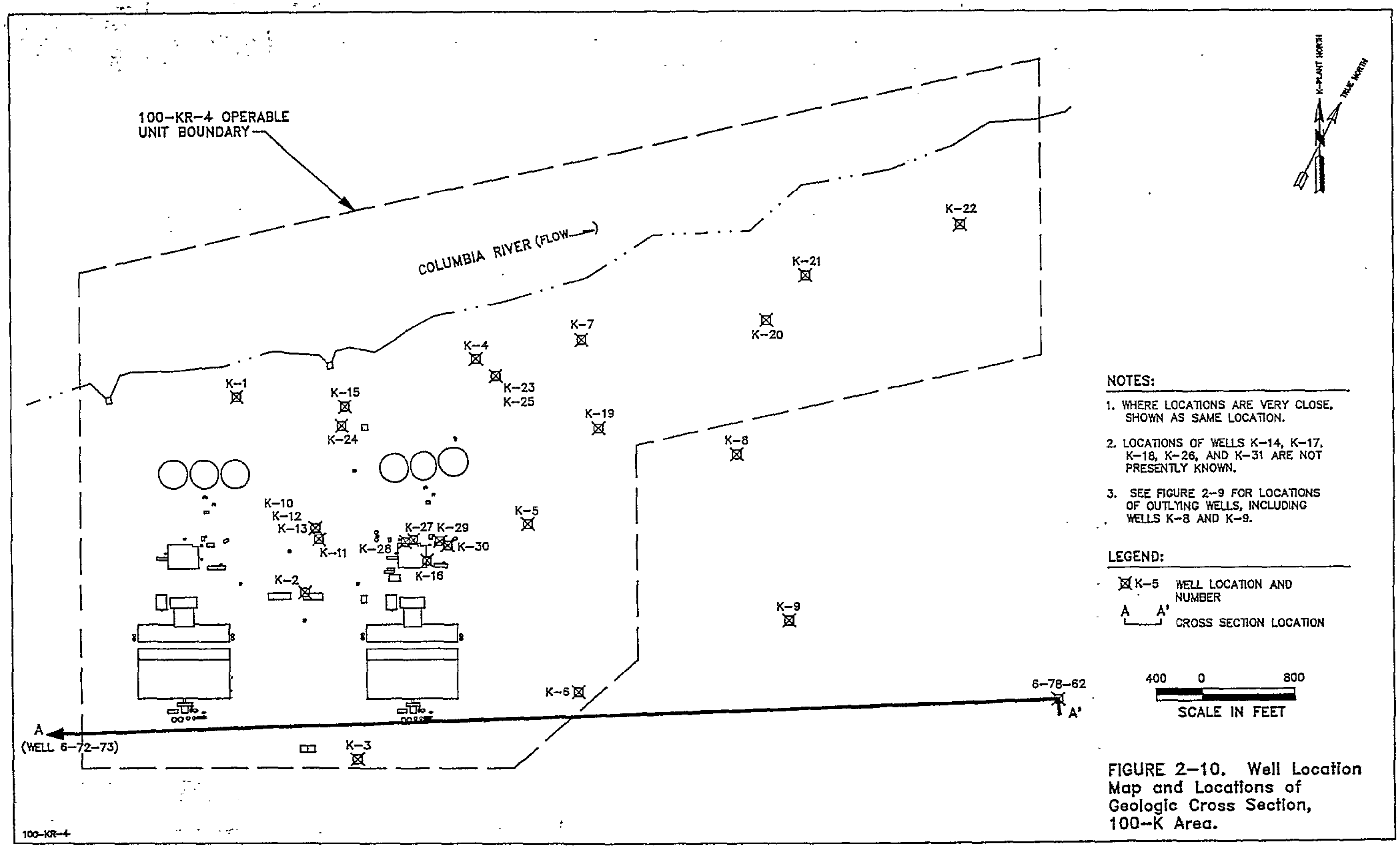


FIGURE 2-10. Well Location Map and Locations of Geologic Cross Section, 100-K Area.

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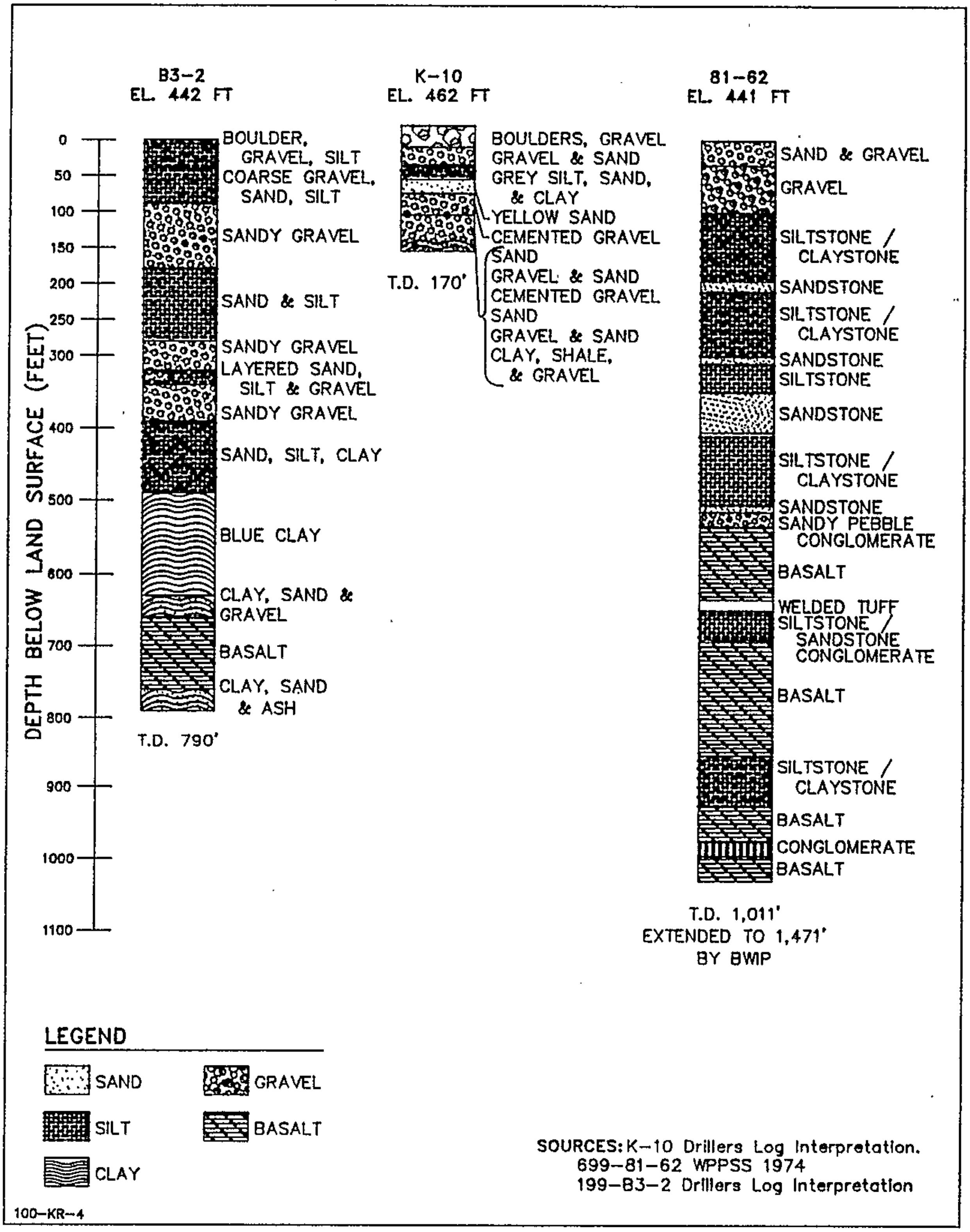

Figure 2-11. Geologic Logs for Wells 199-B3-2, K-10, AND 699-81-62.

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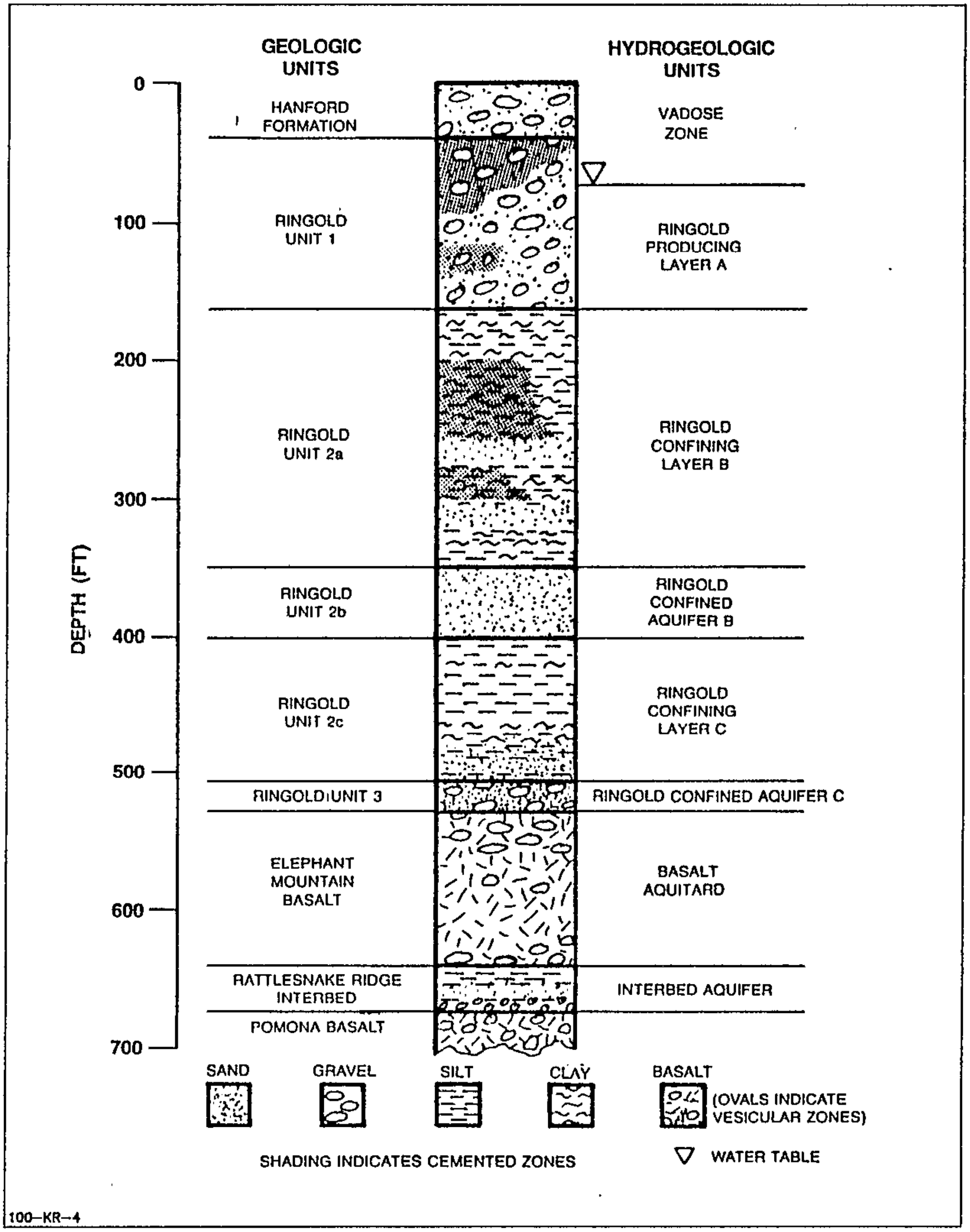

Figure 2-12. Conceptual Geologic and Hydrogeologic Column.

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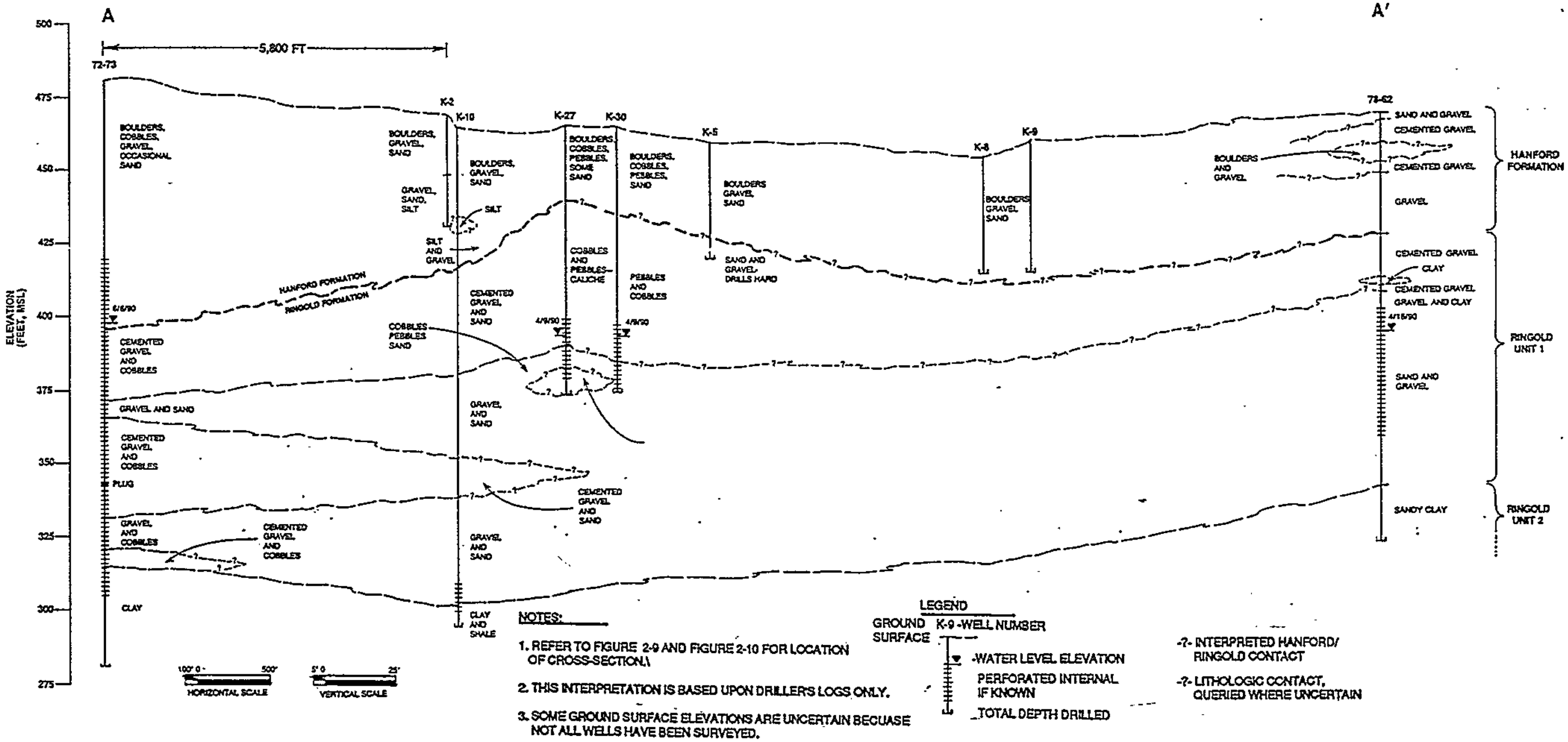

100-KR-4

Figure 2-13. Geologic Cross Section A-A', 100-K Area.

WP 2F-13

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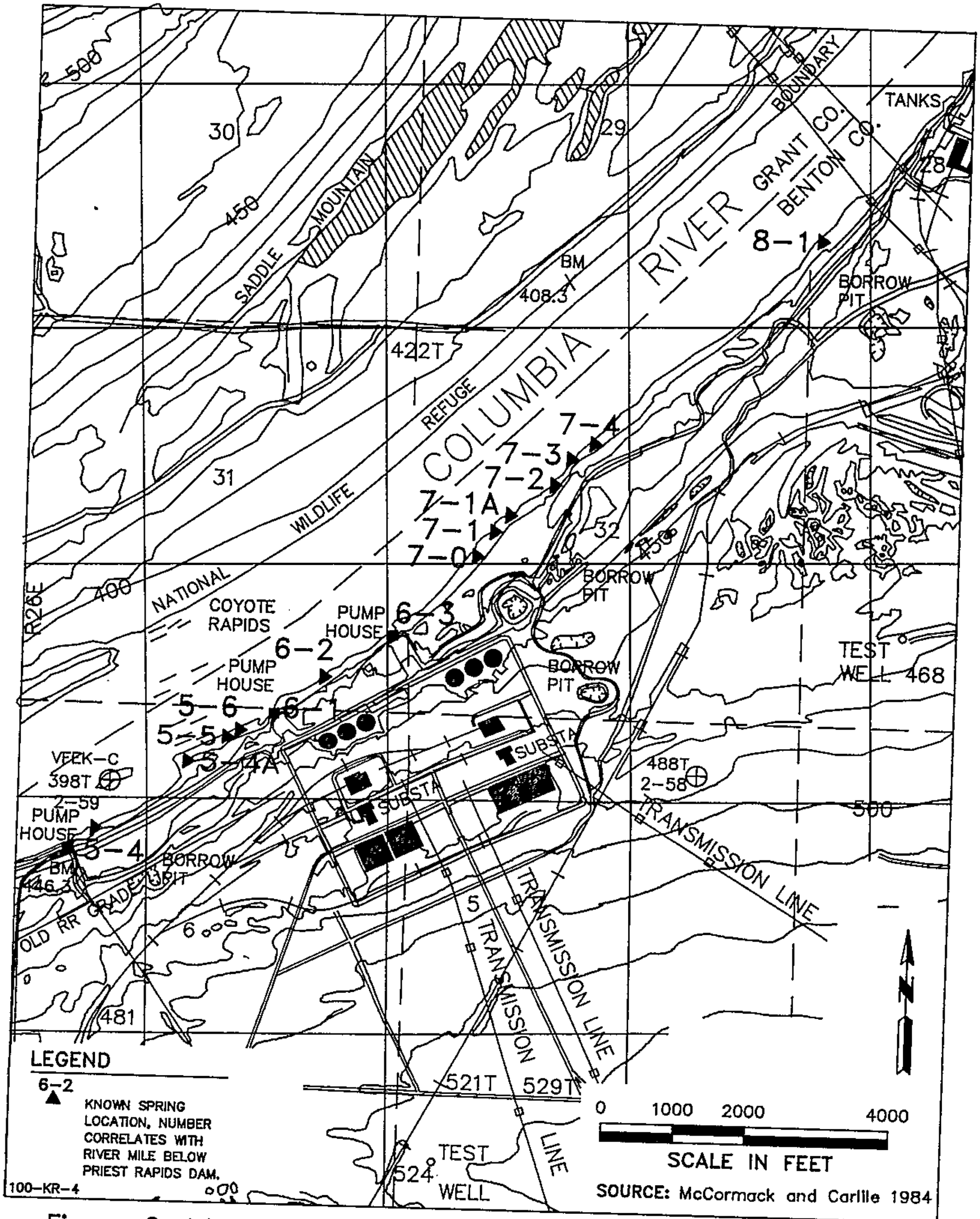
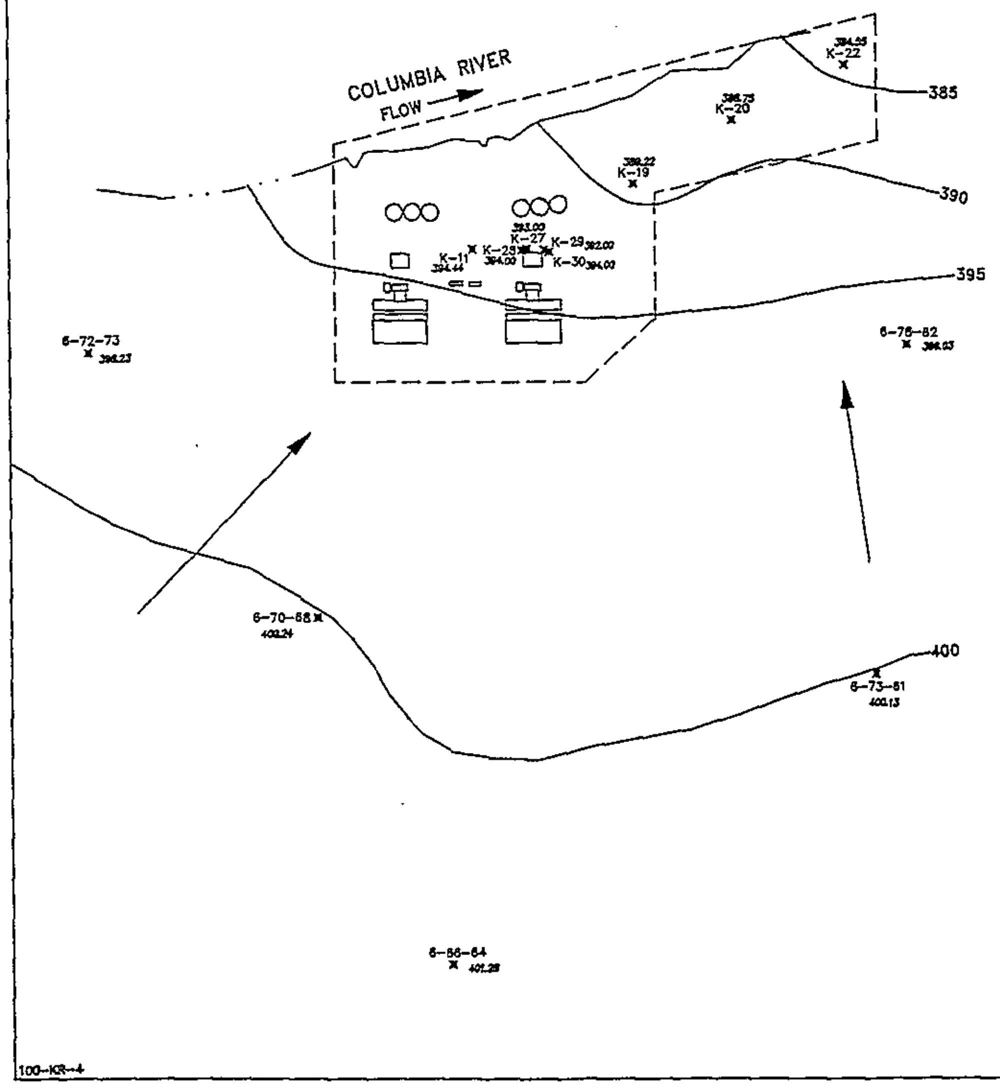


Figure 2-14. Location of Springs Along the Columbia River Shoreline Near 100-K Area.

9 1 1 2 1 . 1 1 7 1 3



WELL	DATE	ELEV (FT. MSL)
K-11	02/16/89	394.44
K-19	02/16/89	389.22
K-20	02/16/89	388.75
K-22	02/16/89	384.55
K-27	02/14/89	393.00
K-28	02/14/89	394.00
K-29	02/14/89	392.00
K-30	02/14/89	394.00
66-64	06/09/89	401.28
70-68	06/09/89	400.24
72-73	05/22/89	398.23
73-61	01/19/89	400.13
78-62	01/19/89	396.03

NOTE:

WATER-LEVEL ELEVATIONS WERE NOT MEASURED AT THE SAME TIME FOR WELLS IN THE K-AREA AND 600 AREA. WATER-LEVELS IN THE 600 AREA WELLS VARIED LESS THAN 1.5 FT BETWEEN VARIOUS MEASUREMENT DATES IN 1989 AND THEREFORE MEASUREMENTS SHOULD BE ADEQUATE FOR DETERMINING GENERAL GROUND WATER FLOW DIRECTIONS.

LEGEND

6-73-61 — WELL, LOCATION, AND DESIGNATION

385 — WATER TABLE ELEVATION CONTOUR (IN FEET)

GENERAL FLOW DIRECTION

2000 1000 0 2000

SCALE IN FEET

FIGURE 2-15. Water Table Contour Map of the 100-K Area in 1989.

KR-1-4\901-2-15.DWG

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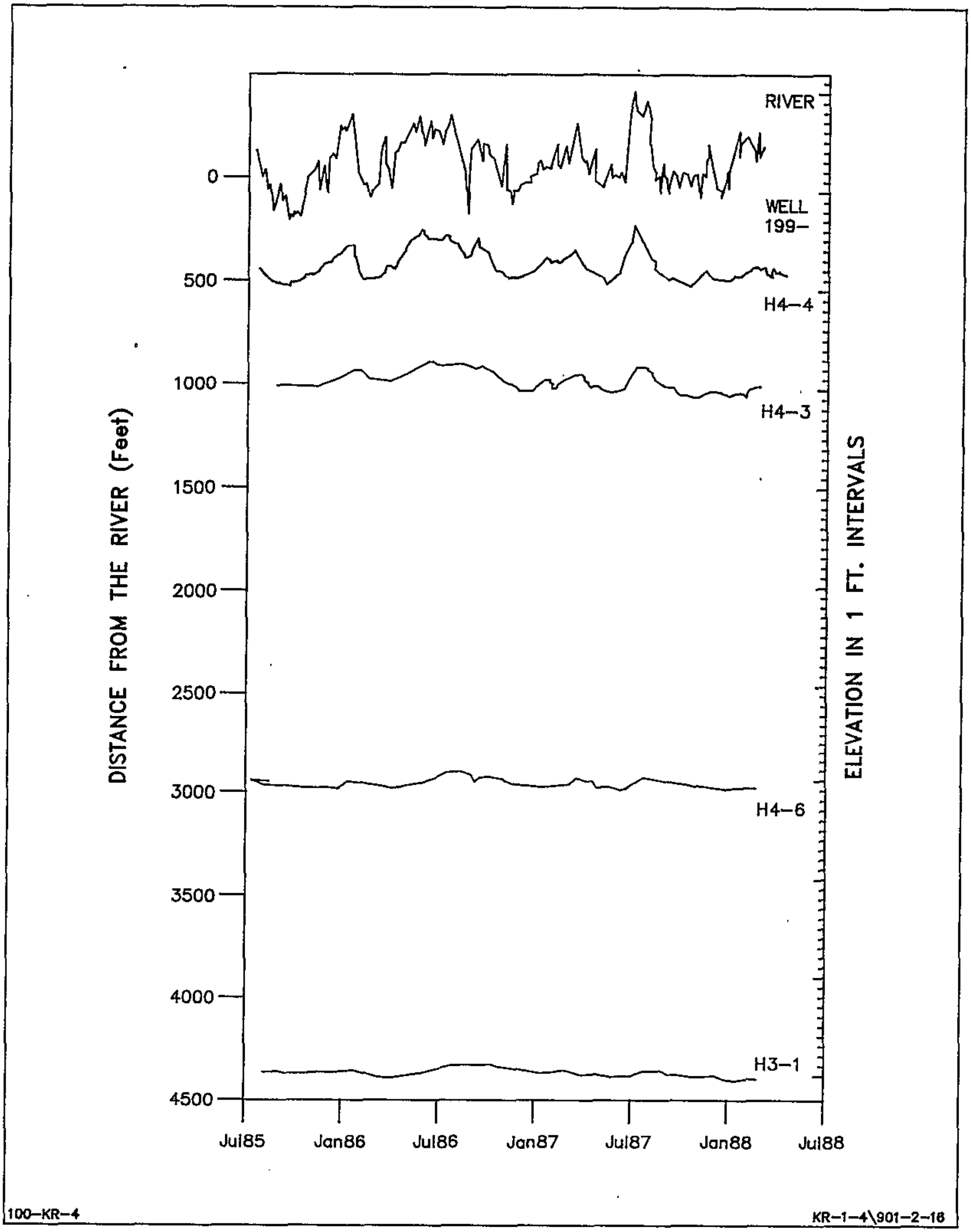

Figure 2-16. Hydrographs of Select 100-H Area Wells.

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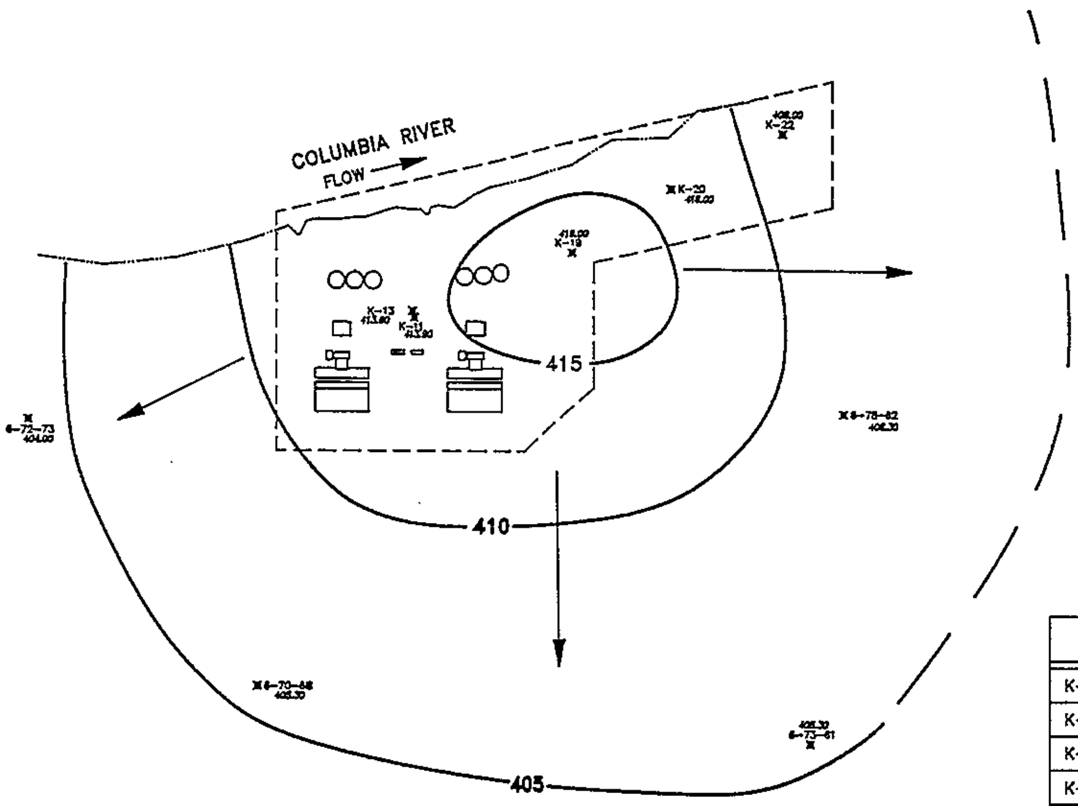

WELL	DATE	ELEV (FT. MSL)
K-11	10/12/67	413.94
K-13	10/12/67	413.64
K-19	10/19/67	419.05
K-20	10/19/67	416.87
K-22	10/19/67	408.06
70-68	10/19/67	405.31
72-73	10/19/67	404.02
73-61	10/19/67	405.33
78-62	10/12/67	407.34

NOTE:

HEAD DATA WERE TAKEN FROM THE HANFORD GROUNDWATER DATABASE. NOT ALL WELLS WERE SAMPLED ON THE SAME DATE. MAP CONTOURS WERE CREATED FROM THE BEST AVAILABLE LIMITED DATA. DATES CLOSEST TO 10/19/67 WERE SELECTED TO ALLOW INTERPOLATION BETWEEN BORE HOLES. WELLS SELECTED WERE CONSTRUCTED IN DIFFERENT GEOLOGIC HORIZONS WHICH MAY CONTRIBUTE TO LOCAL VARIATION IN HYDROLOGIC HEAD. SOME WELLS WERE SCREENED IN MULTIPLE HORIZONS ALSO CONTRIBUTING TO VARIATION WITH ACTUAL CONDITIONS.

LEGEND

6-73-61 WELL AND WELL DESIGNATION

GENERAL FLOW DIRECTION

2000 1000 0 2000

SCALE: 1" = 2000 FEET

FIGURE 2-17. Water Table Contour Map of the 100-K Area in 1967.

100-KR-4

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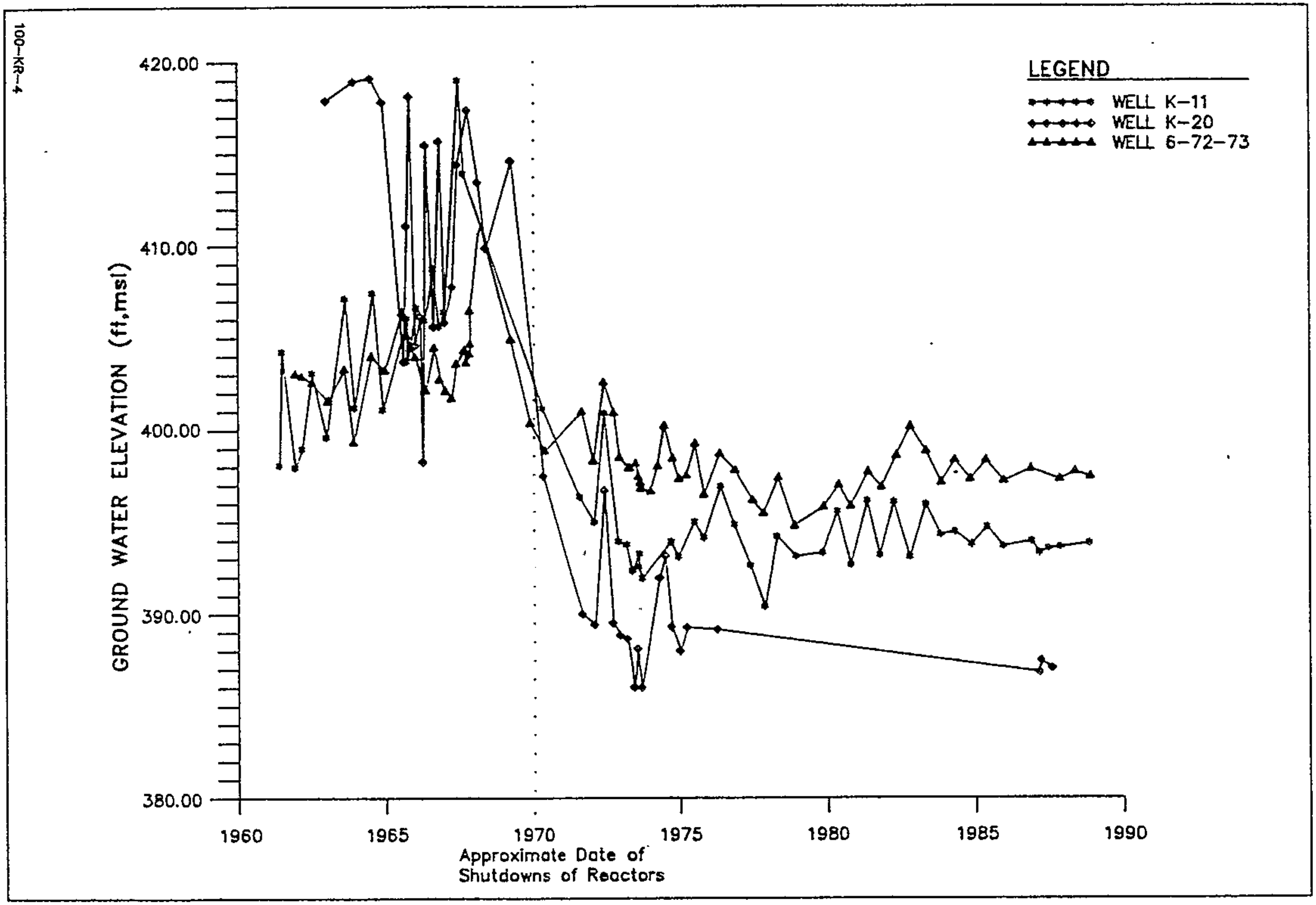

Figure 2-18. Ground Water Elevation vs. Time, 100-K Area.

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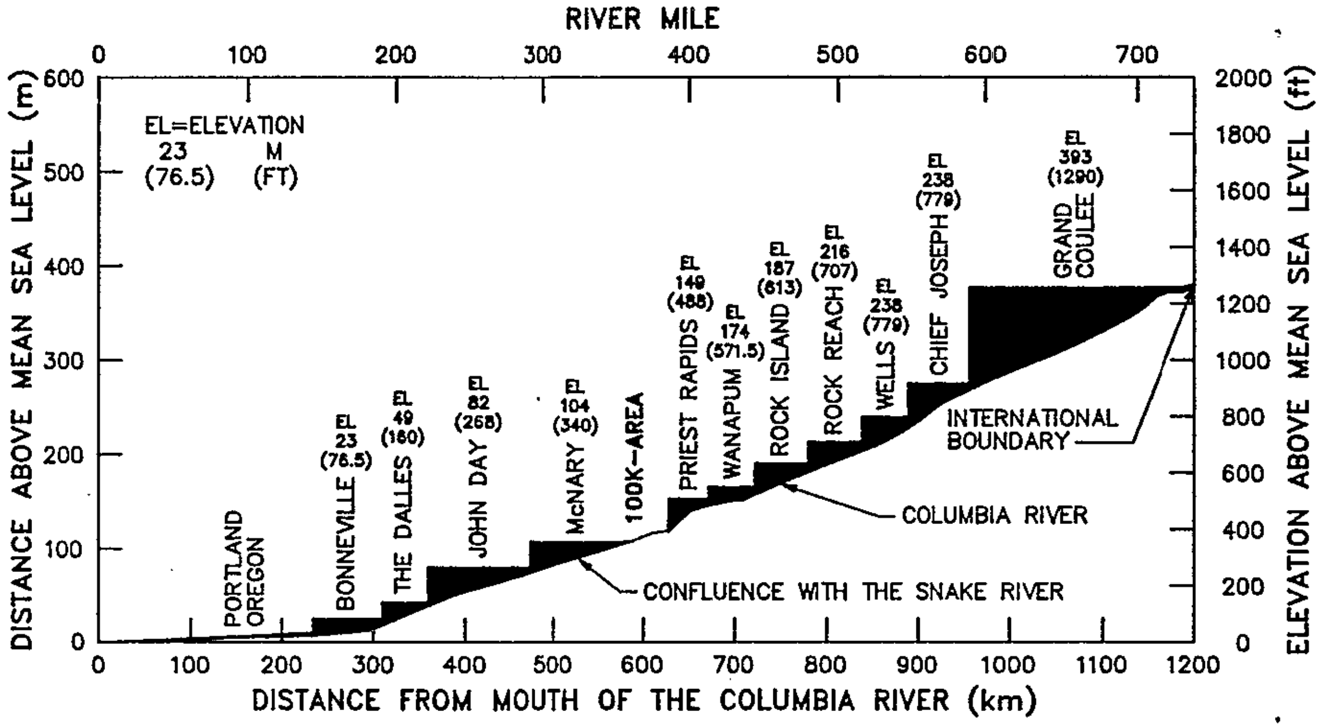
100-KR-4



SOURCE: DOE-RL 1982

Figure 2-19. Profile of the Columbia River.

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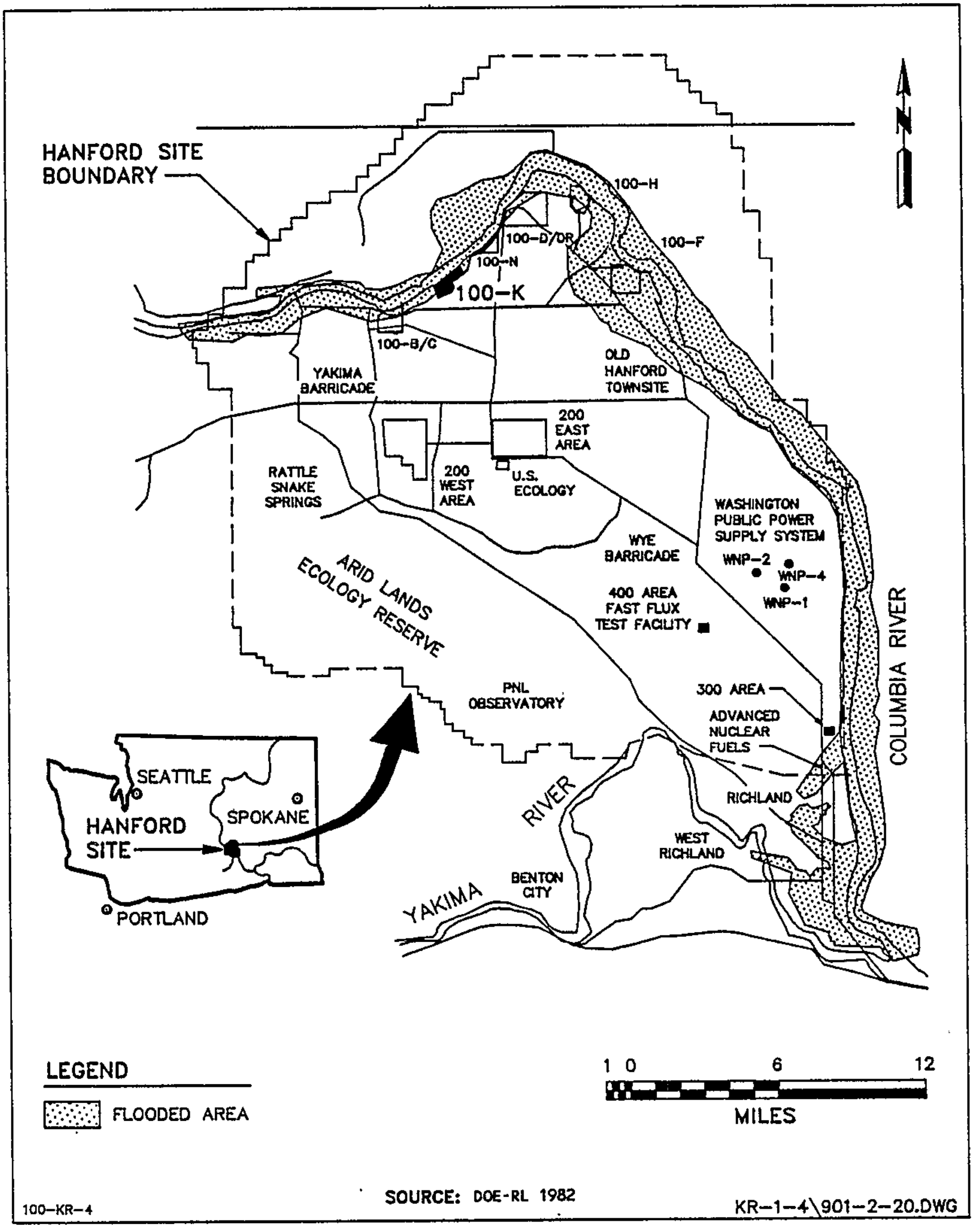

Figure 2-20. Flooded Area at the Hanford Site for the Probable Maximum Flood.

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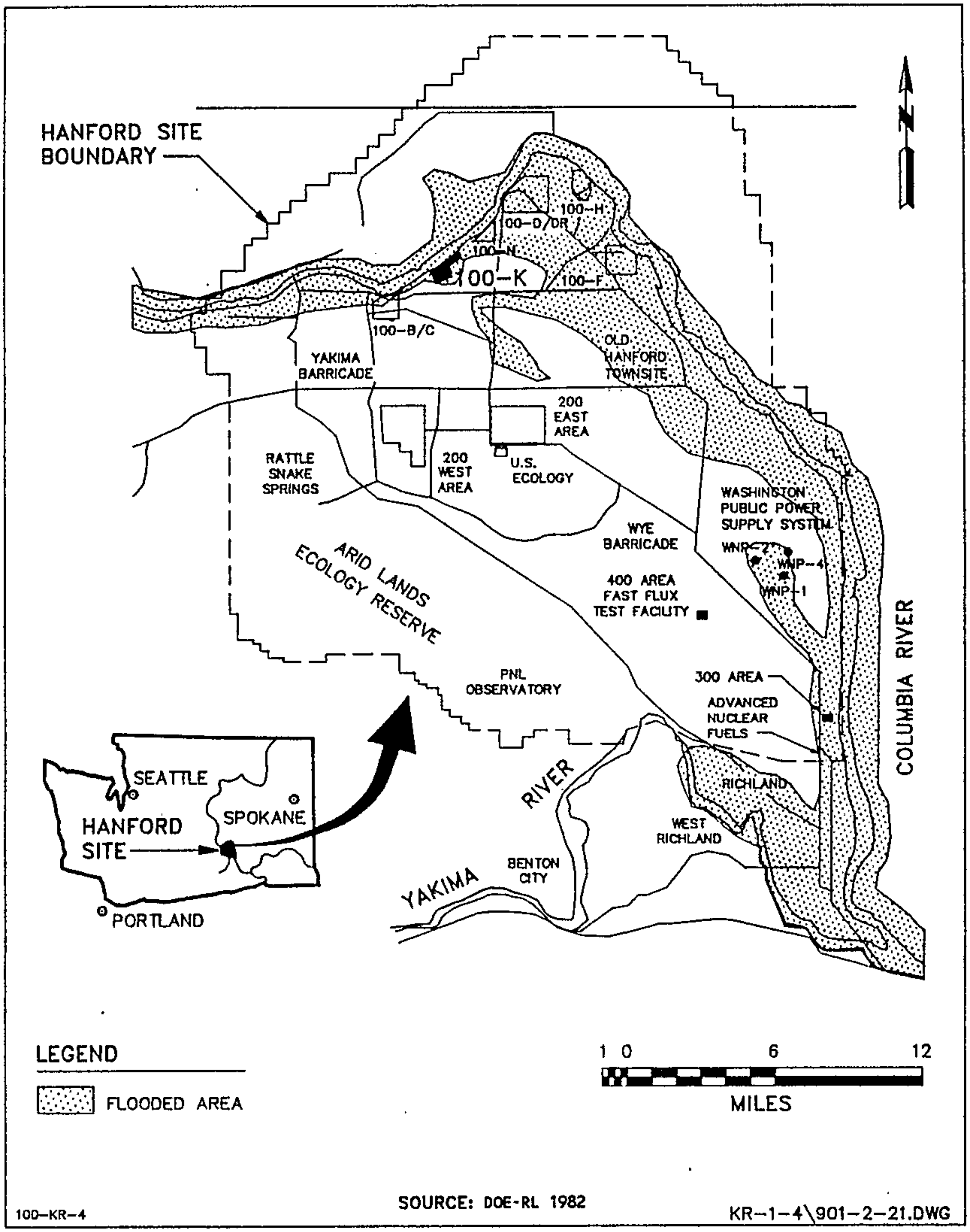

Figure 2-21. Flooded Area at the Hanford Site Resulting from a Hypothetical 50 Percent Breach of Grand Coulee Dam.

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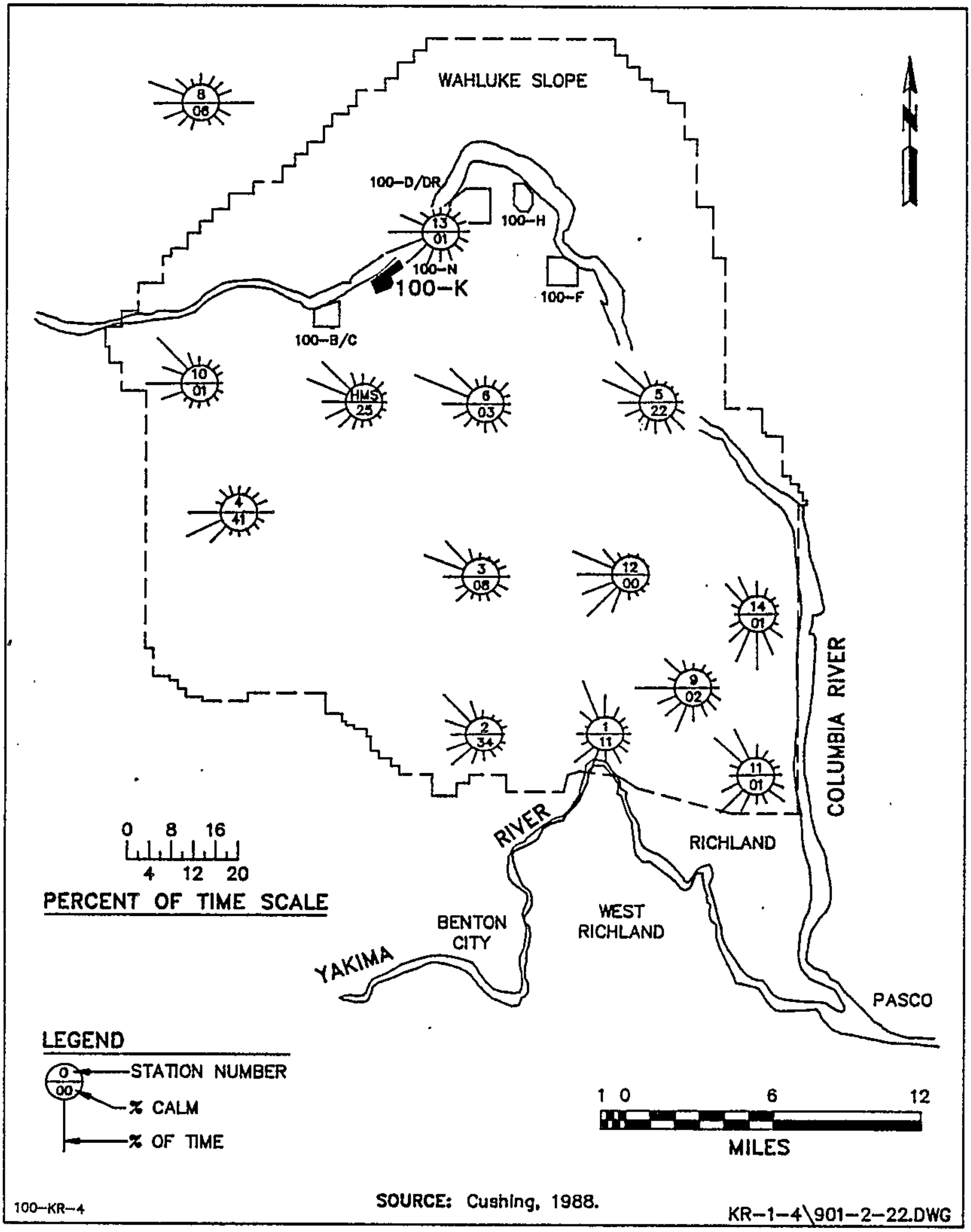

Figure 2-22. Hanford Site Wind Roses.

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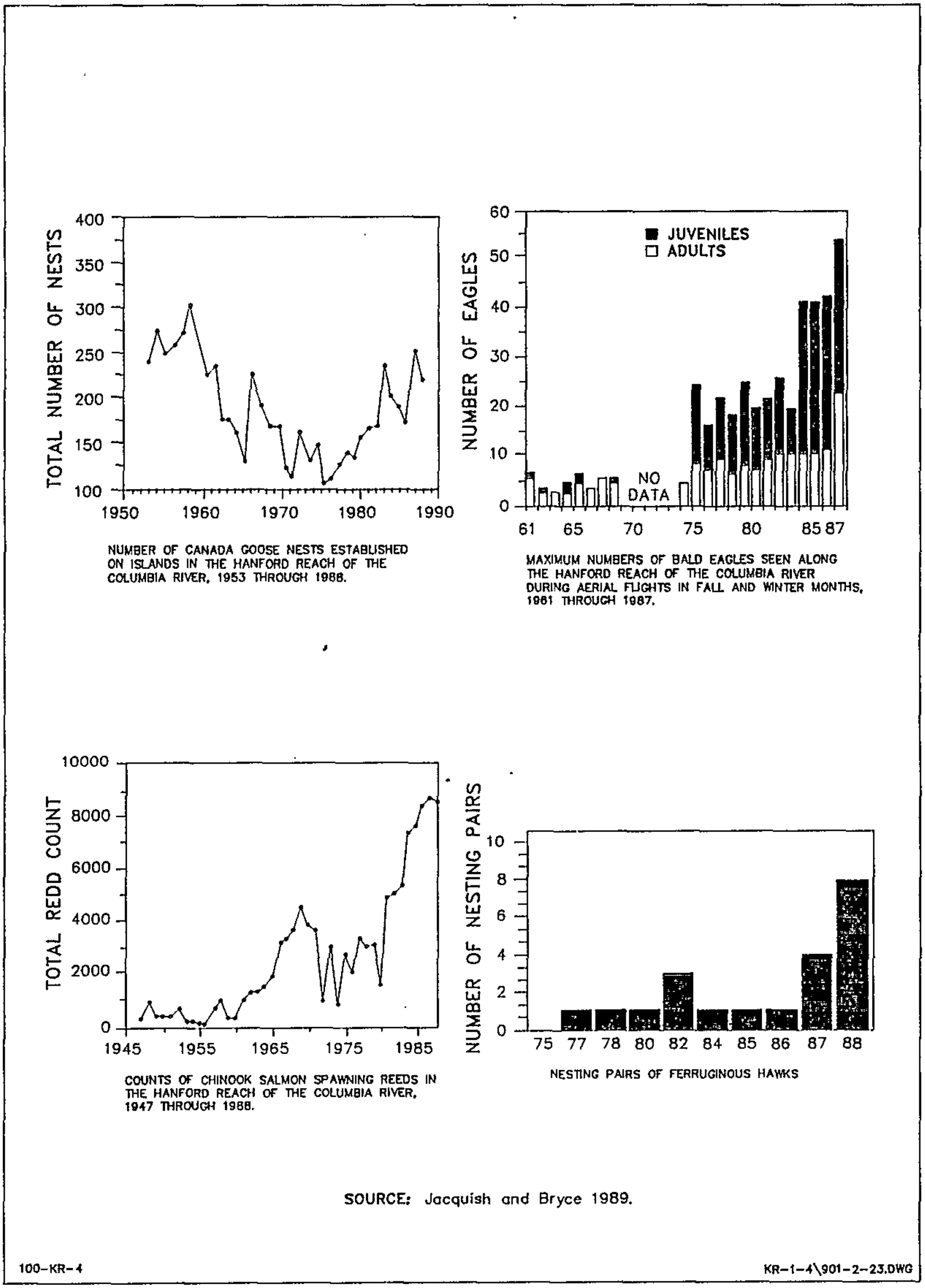

Figure 2-23. Wildlife, Fish and Bird Statistics at the Hanford Site.

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Table 2-1. History of 100-K Area Operation.

Date	Event
1954	Construction completed on 105-KW and 105-KE reactors
1955-1970	105-KW reactor in operation to produce plutonium
1955-1971	105-KE reactor in operation to produce plutonium
1970-1971	Reactors shut down, systems deactivated and decontaminated. A major part of deactivation was removal of the fuel
1973-1974	105-KE and 105-KW reactor basins cleaned and equipment modified to store N reactor irradiated fuel
1974	105-KE basin leak detected
1974-mid-1976	105-KE and 105-KW basin cooling systems modified to closed system cooling and 105-KE basin leak repaired
1975	N reactor irradiated fuel storage begins in 105-KE and 105-KW reactor basins
1975-1977	Study performed to establish radionuclide levels in 100-K Area vadose (Dorian and Richards 1978)
1977	105-KE basin leak detected
1977-1980	105-KE basin further modified and repaired to curtail leak
1987-1988	Preliminary assessment/site investigation completed; 100 Areas nominated to National Priorities List
1989	Shipments of N reactor irradiated fuel cease

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Table 2-2. Facilities Within the 100-K Area. (sheet 1 of 5)

Facility designation	Name	Years in service	Facility purpose	Facility description
100-KR-1 Operable Unit:				
181-KE	River pump-house	1955-present	Pump river water to water treatment plant	Reinforced-concrete intake structure
181-KW	River pump-house	1955-1970	Pump river water to water treatment plant	Reinforced-concrete intake structure
1908-K	Outfall structure	1955-present	Control effluent discharge from 107-KE and 107-KW retention basins and secondary cooling water from reactor basins; continues to control secondary coolant discharge	Reinforced-concrete structure; two steel inlet pipes, two 84-in. steel effluent pipes, overflow channel
1904-K	Radioiodine monitoring building	1955-1971	Monitor radioactivity of effluent	15- by 15-ft wood frame with transite siding and on concrete pad
107-KE	Retention basins	1955-1971	Provide retention of reactor cooling water before discharge into river	Three 250-ft-dia, 9,000,000-gal, welded carbon steel tanks, mounted on a reinforced-concrete foundation
107-KW	Retention basins	1955-1970	Provide retention of reactor cooling water before discharge into river	Three 250-ft-dia, 9,000,000-gal, welded carbon steel tanks, mounted on a reinforced-concrete foundation
116-K-2	Effluent trench	1955-1971	Percolation of radioactive reactor cooling effluent	4,000- by 50-ft, gravel-lined percolation trench including four overflow areas
116-K-1	Effluent crib	1955	Percolation of radioactive reactor cooling effluent	200- by 200- by 20-ft percolation crib
100-KR-2 Operable Unit:				
105-KE/KW	Waste tank	1975-present	Storage	9- by 40-ft PVC-lined steel tank 24 ft north of buildings
105-KE/KW	C sump	1975-present	Reactor basin	Concrete sumps 7.5- by 4.6- by 12-ft to collect overflow drainage at reactor basin sump
105-KE/KW	Reactor buildings	KE 4/55-1/71 KW 1/55-2/70	Provide housing for reactors and ancillary facilities	Reinforced-concrete and steel multistory structure; houses reactor, control room, offices, lunch room, spent-fuel storage, ventilation systems
110-KE/KW	Gas storage associated with 115-KE/KW buildings	1955-1971	Gas storage for 115-KE and 115-KW buildings	Reinforced-concrete

Table 2-2. Facilities Within the 100-K Area. (sheet 2 of 5)

Facility designation	Name	Years in service	Facility purpose	Facility description
115-KE/KW	Gas recirculation building	1955-1971 Demolished in 1988	Houses gas-circulating pumps and associated equipment and reactor gas coolant system	Single-story reinforced-concrete structure; tunnel connects to 105 reactor building; considered a major contaminated structure
116-KE/KW	Reactor exhaust stacks	1955-1971 Top 125 ft decontaminated in 1982, partially dismantled in 1988	Discharged reactor building exhaust air	Reinforced monolithic concrete, 30- by 22-ft-dia at base, top 125 ft dismantled; rubble was placed in remaining base of stacks
117-KE/KW	Exhaust air filter building	1955-1971 Demolished 1988	Filter ventilation air from reactor buildings; houses air filters and airflow control system	Reinforced-concrete building built mostly underground, 59- by 39- by 35 ft high; connected by tunnels to 105 reactor building and 116 exhaust stack; structure demolished and buried in situ in 1988
118-K-1	100-K Area waste burial ground	1954-1973	Burial of solid waste from the 100-K Area	1,200- by 600-ft burial ground; contains numerous trenches and pits; surface routinely treated with herbicide, contains large radionuclide inventory
120-KE-6	Brine pit	1966-1971	Mix salt brine	Concrete 10- by 20- by 20-ft subsurface pit to mix salt brine for water softeners
120-KE-8	Brine pit	1966-1971	Mix salt brine	Concrete 10- by 20- by 20-ft subsurface pit to mix salt brine for water softeners
128-K-2	Burn pit	Unknown	Burn waste	Surface burning of chemicals and misc. waste - later used for asbestos burial
	Glycol tanks	1955-present	Store glycol	At KE/KW reactor buildings ethylene glycol was used in heat exchangers for building space heaters
165-KE/KW	French drains	1955-1971	Unknown	Located west of glycol tanks - use unknown
166-KW	French drains	1955-1971	unknown	Located west of glycol tanks - use unknown
151-KE/KW	Electrical substation area	1955-present	Provide power distribution	Approximately 3 acres of land containing transformers and switch gear

Table 2-2. Facilities Within the 100-K Area. (sheet 3 of 5)

Facility designation	Name	Years in service	Facility purpose	Facility description
165-KE/KW	Power control buildings	1955-present	Houses powerhouse, control room, valve pit, and electrical switch gear for water supply building	Single-story concrete structure; consists of the pump room and valve pit, electrical area, oil-fired steam plant, and control room; tunnel from 183 water filter plant to 105 reactor building; the 165-KE oil boiler provides heat for the remaining facilities in the 100-K Area
166-KE/KW	Fuel oil storage and pumps associated with 165-KE/KW buildings	1955-1971	Storage and pump facilities for fuel oil for the oil-fired steam plant in the 165-KE/KW buildings	Underground 1,650,000-gal fuel oil storage bunkers
167-K	Cross-tie tunnel vent	1955-present	To provide ventilation between 190-KE and 190-KW	A reinforced-concrete tunnel vent
182-K	Emergency water pump building	1955-1971	Provides emergency pumping capacity from the clearwells to the 105 reactors; houses three diesel-engine-driven pumps, air compressors, fuel tanks, batteries, and charging equipment	Steel-framed structure with concrete foundation and transite walls; two 17,500-gal fuel tanks are associated with this structure
190-KE/KW	Main pump-houses	KE 1955-present KW 1955-1971	Provides primary coolant for the 105 reactors; houses process and service water pumps, powerhouse, electrical substation, valve pit, and control room	Single-story building with concrete basement and floors, steel frame, and transite walls; 190-KE, deactivated in 1971; 190-KE, presently used to supply water to the fuel storage basins, fire protection, and domestic water needs
1702-KE/KW	105-Area badge houses	1955-1980's	Security and personnel dosimetry	Single-story, concrete and steel frame with transite walls
1704-K	Administrative building	1954-present	Provides office space and first aid center	Single-story, concrete and steel frame with transite siding
1706-KE	Testing facilities	1955-present	Provides out-of-reactor test facilities in support of in-reactor test loops and single-pass tubes to study corrosion and effects of water treatment on effluent	Single-story, concrete and steel frame with transite siding; full basement; provides water treatment facilities and instrumentation for eight reactor tubes used to study corrosion and effects of waste treatment on effluent

Table 2-2. Facilities Within the 100-K Area. (sheet 4 of 5)

Facility designation	Name	Years in service	Facility purpose	Facility description
1706-KER	Testing facilities	1955-present	Provides out-of-reactor facilities in support of in reactor testloops and single-pass tubes to study corrosion and effects of water treatment on effluent	Single-story, concrete and steel frame with transite walls shielded cells below grade
1706-KEL	Testing facilities	1955-present	Lab for 1706-KE and 1706-KER testing facilities	Single-story concrete and steel frame
1713-KE	Shop building	1954-1980's	Storage	Sheet metal with concrete floor
1713-KER	Warehouse	1950's-1970's	Storage	Sheet metal with concrete floor
1713-KW	Warehouse	1950's-1970's	Storage	Sheet metal with concrete floor
150-KE/KW	Heat recovery facilities	KE 1955-1971 KW 1955-1970	Heat recovery from cooling water effluent	Unknown
Experimental Radiation Exposure	Fish tanks	About 1956-1960		Conducted fish development experiments in reactor effluent waters
Process Drainage Coll. boxes	Drainage coll.	Unknown	Collect sump drainage	Concrete 8- by 8- by 8-ft collection boxes for reactor building sumps and drains
Tank Silo	Catch tank	1975-present	Building drain	Concrete and steel silo, 35 ft deep used to catch sub-basin drainage
100-KR-3 Operable Unit:				
1701-K	Area badge house	1954-1980's	Security and personnel dosimetry	Single-story, concrete and steel frame structure with transite walls; adjoins 1720-K building
1720-K	Area headquarters	1954-present	Headquarters for security patrol, mail operations	Single-story, concrete and steel frame construction with transite siding; adjoins 1701-K building
183-KE/KW Facilities	Water treatment facility	KE 1955-present KW 1955-1970's	Process water and domestic water treatment	See 183.1, 183.2, 183.3, 183.4, and 183.5 structures described below
183.1 KE/KW	Headhouse and chlorine building	1950'-1970's	Contains a lab sample room, chlorinator room, switchgear room, and operational area housing chemical feed equipment, storage tanks, water softeners, and pumps	Single-story, concrete and steel frame structure with transite siding

Table 2-2. Facilities Within the 100-K Area. (Sheet 5 of 5)

Facility designation	Name	Years in service	Facility purpose	Facility description
183.2 KE/KW	Flocculation and sedimentation	1950's-1970's	Water treatment	Open-air concrete basins, with mixing chambers, agitators, flumes; each facility (KE/KW) covers about 288,000 ft^2
183.3 KE/KW	Filter basin	1950's-1970's	Water filtration	Concrete basin containing a granular media filter with about 65,000 ft^2 of surface area; gravity flow-through filter
183.4 KE/KW	Clearwells	1950's-1970's	Treated water storage	Concrete basin used to store treated water; two clearwells of 9,000,000-gal capacity are used at each 105 reactor
183.5 KE/KW	Lime houses	1950's	Lime storage, and feeding lime to filtered water in clearwells	Transite and steel
183.6 KE/KW	Feeder buildings	1950's-1970's	These facilities were cross-tie buildings between the KE and KW areas	Concrete and steel

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Table 2-3. Construction Information for Wells in the Vicinity of the 100-K Area. (sheet 1 of 2)

Well[a] number	Hanford coordinates[b]		Casing elevation (ft, msl)	Casing diameter (in.)	Well depth (ft)[c]	Screened interval		Date completed	Comments
	West	North				From (ft)	To (ft)		
100-KR-1 Operable Unit									
K-1[d]	69930	76800	405[e]	8	107	---[f]	---	3/31/52	Casing removed
K-4	68220	78052	405	8	40	---	---	3/31/52	Casing removed
K-7	67480	78620	406	8	42	---	---	2/28/52	Casing removed
K-13	68803	76104[h]	464	12	170	---	---	3/31/52	Oil in well, T.D. 138′[g]
K-19	67000	78000	422.17	8	51	26	46	4/30/55	P-Sub[g]
K-20	66125	79500	422.57	8	50	10	50	5/31/55	P-Sub, T.D. 48′
K-21	66000	80000	421.73	8	50	10	50	5/31/55	T.D. 16′
K-22	65000	81000	421.68	8	50	29	49	5/31/55	P-Sub, T.D. 49′
K-23	68000	78000	405	8	80	65	80	2/28/56	T.D. 25′
K-24	69000	77000	467	8	50	---	---	12/31/52	---
K-25	68000	78000	405	8	76	50	75	8/31/53	---
100-KR-2 Operable Unit									
K-2	68628	75569	469	6	40	---	---	2/28/52	Casing removed
K-5	67175	76975	460	6	40	---	---	1/31/52	Casing removed
K-10	68800	76100	466.66	12	171	155	165	8/31/52	T.D. 160′
K-11	68733	76030	467.66	6	170	69	160	8/31/52	P-Sub, T.D. 138′
K-15	69050	77160	408	6	150	---	---	4/30/43	---
K-16	67800	76300	404	8	50	---	---	2/28/53	---
K-27	68000	76400	465	6	90	65	85	9/30/79	P-Sub
K-28	68060	76350	465	6	90	63	88	9/30/79	P-Sub, T.D. 88′
K-29	67775	76500	465	6	90	65	85	9/30/79	P-Sub, T.D. 89′
K-30	67700	76500	465	6	90	67	87	10/31/79	P-Sub, T.D. 87′
100-KR-3 Operable Unit									
K-3	67582	74493	495	6	40	---	---	8/31/52	Casing removed
K-6	66131	75889	480	6	40	---	---	1/31/52	Casing removed
K-12	68803	76104	466.55	6	159	118	138	9/30/52	Covered over

Table 2-3. Construction Information for Wells in the Vicinity of the 100-K Area. (sheet 2 of 2)

Well[a] number	Hanford coordinates[b]		Casing elevation (ft, msl)	Casing diameter (in.)	Well depth (ft)[c]	Screened interval		Date completed	Comments
	West	North				From (ft)	To (ft)		
600 (Background)									
K-8	65733	78371	455	6	40	---	---	2/28/52	Casing removed
K-9	64688	77295	470	8	40	---	---	2/28/52	Casing removed
6-66-64	64249	66483	505.92	6	120	96	116	6/30/72	P-Sub
6-70-68	68357	70123	526.21	8	149	126	147	7/31/54	P-Sub, plug at 146′
6-72-73	73222	72038	482.57	8	200	60	176	9/30/61	P-Sub, plug at 135′
6-73-61[i]	60527	73195	531.53	8	150	95	135	9/14/62	P-Sub
6-74-74	74075	73650	438	6	65	---	---	---	Filled in
6-77-54	54100	76700	480.59	8	150	70	120	5/57	P-Sub, plug at 120′
6-78-62[e]	62300	77750	469.88	8	150	67	107	5/31/57	P-Sub, T.D. 109′
6-80-62	62000	81900	440	---	---	---	---	---	---
6-81-62	62072	80813	441.46	2	1,471	1,280	1,322	3/31/73	---
B/C Area									
B3-2	71752	78818	442.59	8	790	635	645	8/53	Deep-basalt
Wells Not Currently Located by Coordinates									
K-14	---	---	469.05	8	95	---	---	12/52	---
K-17	---	---	406	8	75	50	75	9/53	---
K-18	---	---	409	8	60	---	---	10/54	---
K-26	---	---	464	8	15	---	---	8/53	---
K-31	---	---	---	6	50	30	50	5/86	---

Sources: McGhan 1989 and drillers' logs.

[a]Well numbers are abbreviated. Full numbers for "K" series wells would be 199-K-# and they are sometimes abbreviated 1-K-#. The "6" series wells, such as 6-81-62, would be 699-81-62.
[b]Well locations are shown on Figure 2-9 and 2-10.
[c]Depth from drillers log at time of drilling. Several boreholes have filled in, therefore the most recently measured depth is indicated in comments column.
[d]Complete information is not currently available for wells K14, K17, K18, K26, and K31.
[e]Elevations presented to the nearest foot are assumed to have not been surveyed and therefore may be in error by several feet.
[f]Dashes (---) indicate data not available.
[g]T.D. = total depth; P-Sub = submersible pump.
[h]Coordinates presented to the nearest 100 ft are assumed to have not been surveyed and therefore may be in error
[i]Log for 6-73-61 originally designated as 699-74-60.

Table 2-4. History of Well Installation in the 100-K Area.

Time frame	Well number	Purpose
1943	K15	Unknown (rediscovered in 1953)
1952 1953	K1 to K14, K24 K16, K17, K25	Presumably installed to evaluate overall conditions of 100-K Area
1954	K18	Unknown
1955	K19 to K22	Presumably installed to evaluate overall conditions of 100-K Area
1979	K27 to K30	Four wells to determine impact from 105-KE fuel storage basin
1986	K31	Supplement 1979 wells
1966-1981	"6" Series Wells	Installed to evaluate overall conditions of 100 Areas

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Table 2-5. Shoreline Springs Inspection Record in Vicinity of 100-K Area.

Location[a]	Location[b]	Designation[c]	Description[d]
5.25	382.85	5-4	17.3°C, moderate flow, several small springs at river's edge 60 yd DS RM 5-3.
5.6	382.5	5-4A	12.3°C, low flow, 100 yd DS pump station.
		5-5	10.2°C, moderate flow, 50 yd DS 5-4A, percolating.
5.9	382.2	5-6	12.8°C, moderate flow, continuous to RM 6 (50 yd).
6.0	382.1	6-1	12.9°C, moderate flow, percolating continuous for 50 ft, 150 yd DS RM 6.
6.2	381.9	6-2	10.1°C, low flow, percolating stream, 75 yd DS boat launch area.
		6-3	8.8°C, low flow, 75 yd DS 100-KW intake.
6.8	381.3	7-0	13.2°C, heavy flow, inside narrow inlet extending inland 10 yd from river's edge, 200 yd DS 100-KE intake, inlets surrounded large boulders and cobble; 20 ft DS is another inlet, low flow 12.0°C.
6.9	381.2	7-1	11.9°C, moderate to low flow, emanating from small boulders at DS inlet from small point, 4 ft from river's edge, 100 yd DS is another area low flow 12.5°C (at RM 7).
7.0	381.1	7-1	13.8°C, heavy flow, 5 yd from river's edge, cobble and boulders, 150 ft DS RM 7, on small point; 10 yd DS is second area heavy flow 13.0°C; 30 yd DS is third area heavy flow 14.6°C, 6 ft from river's edge; 36 yd total DS 7-1 fourth area heavy flow 15.1°C, broad area of springs (directly below K-19 well)-unnumbered well with water in it here, - at K trench overflow, broad area, low flow 12.2°C (BM site sign) - 8:10 a.m.
7.25	380.85	7-2	15.4°C, moderate flow, area 15 ft wide, small inlet at DS end of depressed K trench overflow area, 6 ft from river's edge.
		7-3	11.2°C, moderate flow, 100 ft S no trespass sign, 100 ft DS from 7-3, intermittent flow DS from 7-3.
7.3	380.80	7-4	11.8°C, very heavy flow, forms small pool, boulder area 15 ft from river's edge, bank broad and flat.
8.25	379.85	8-1	12.0°C, low flow, in grooves perpendicular to river, 15 yd from river's edge, flat cobble shore, 500 yd DS RM 8 - 60 ft DS 8-1 12.2°C, percolating vertically from hole between rocks 1 ft from river's edge - 930 a.m. 11.9°C below no trespass sign 5 ft from river's edge.

NOTE: This table includes seeps from RM 5.3 through 7.5. This portion of the river was selected by McCormack and Carlile (1984) to encompass the sections of shoreline adjacent to the 100-K Area. Shoreline inspection was conducted during periods of low river flow.

[a]River mile (RM) from McCormack and Carlile, 1984.
[b]Converted RM to correspond to standards USGS designation.
[c]Spring designation from McCormack and Carlile, 1984.
[d]DS-downstream.

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Table 2-6. Cation Exchange Capacities. (sheet 1 of 3)

Well number	Depth of sample (ft below surface)	Grain size: Material above 2 mm (%)	Grain size: Sand (%)	Grain size: Silt (%)	Grain size: Clay (%)	Cation exchange capacity (meg/100 g)	Lithology (from driller's log)
Wells Within 100-KR-1 Operable Unit							
K19	10	42	54	1.9	1.9	1.4	Gravel and boulders
	15	28	60	7.7	4.9	2.0	Gravel
	20	31	54	9.0	5.8	1.5	Gravel
	25	26	59	9.4	5.9	1.4	Gravel
	30	30	59	7.8	4.2	1.1	Gravel
	35	54	45	0.4	0.9	0.5	Gravel
	40	88	8	1.7	1.0	0.3	Gravel and boulders
	45	29	65	0.9	4.5	1.6	Gravel
K-25	5	35	50	9.9	5.0	3.7	Clay
	10	32	51	11.3	5.5	4.3	Clay and gravel
	15	10	62	20.1	8.7	6.0	Clay and gravel
	20	59	38	1.7	0.9	1.5	Gravel
	25	75	25	0.1	0.3	0.9	Gravel and boulders
	30	31	65	2.5	1.1	1.7	Sand and coarse gravel
	35	21	73	5.9	0.1	1.6	Sand and coarse gravel
	40	41	53	4.3	1.6	1.3	Coarse gravel, boulders and fine sand
	45	57	40	2.4	0.8	1.3	Sand and coarse gravel
	50	59	39	1.2	0.6	0.6	Sand and coarse gravel
	55	52	44	2.9	1.2	1.2	Coarse gravel and sand
	60	50	48	1.9	1.0	1.1	Coarse gravel and sand
	65	60	39	0.9	0.6	0.7	Gravel and sand
	70	49	45	3.6	2.3	0.8	Gravel and sand
	75	59	40	0.7	0.8	0.4	Gravel and sand
K-26	5	21	70	6.3	3.0	4.9	No log available
	10	33	57	7.0	2.9	4.4	
	15	45	54	1.1	0.4	3.4	
	20	32	51	12.0	5.0	5.4	
	25	29	53	13.8	4.55	5.9	
	30	39	55	3.7	2.5	1.2	
	35	24	59	12.9	4.0	1.5	
	40	24	72	2.3	1.7	1.2	
	45	49	49	1.5	0.7	0.4	
	50	38	58	1.6	2.4	1.6	
	55	32	58	7.1	3.2	1.6	
K-18 (questionable location)	5	20	75	2.4	1.7	2.5	Sand backfill
	11	19	76	2.8	1.8	2.0	Sand backfill
	15	61	36	1.9	0.9	0.5	Coarse gravel and coarse
	20	23	71	4.4	2.1	0.1	sand
	25	63	35	0.9	0.4	0.5	Gravel and fine sand
	30	17	79	2.8	0.9	1.2	Gravel and fine sand
	35	0	94	4.5	1.6	1.2	Gravel and fine sand
	40	49	48	2.0	1.2	1.0	Fine sand
	45	47	50	2.1	0.7	1.6	Coarse gravel and fine sand
							Coarse gravel, cobbles, and
	50	37	56	5.4	2.1	1.7	fine sand
	55	61	37	1.0	0.7	1.1	Gravel and fine sand
	60	34	62	2.6	1.5	2.1	Gravel and fine sand
							Coarse gravel and fine sand

Table 2-6. Cation Exchange Capacities. (sheet 2 of 3)

Well number	Depth of sample (ft below surface)	Grain size: Material above 2 mm (%)	Grain size: Sand (%)	Grain size: Silt (%)	Grain size: Clay (%)	Cation exchange capacity (meg/100 g)	Lithology (from driller's log)
Wells in the 600 Area Near the 100-K Area							
6-70-68	5	38	42	14.2	5.2	3.3	Boulders, sand, and silt
	10	40	40	14.4	5.7	3.2	Boulders, sand, and silt
	15	43	43	9.7	4.3	3.0	Boulders and gravel
	20	51	39	6.8	2.7	2.4	Cobbles and gravel
	25	71	23	4.3	1.7	1.5	Coarse gravel
	30	10	84	4.0	1.8	3.9	Fine and coarse sand
	35	28	64	5.5	2.1	3.8	Sand and gravel
	40	5	90	4.0	1.4	5.1	Sand
	45	10	84	4.2	1.8	6.8	Fine sand
	50	57	41	0.9	0.6	1.6	Sand and gravel
	55	37	50	10.8	1.5	3.1	Sand and gravel
	60	25	69	3.6	1.6	2.8	Sand and gravel
	65	16	62	20.6	1.8	3.1	Sand and gravel
	70	19	60	19.9	1.7	3.0	Sand and gravel
	75	65	31	2.7	1.3	1.6	Gravel and sand
	80	75	22	1.8	1.2	1.7	Gravel and sand
	85	7	89	2.8	0.7	3.0	Gravel and sand
	90	40	57	2.1	0.8	2.9	Gravel and sand
	95	17	79	3.3	1.1	4.1	Gravel and sand
	100	5	88	5.7	1.7	4.9	Sand
	105	49	45	4.9	1.7	2.8	Gravel and sand
	110	59	33	6.1	1.9	2.6	Gravel and sand
	115	27	68	3.7	2.0	2.6	Gravel and sand
	120	11	85	3.2	1.1	2.6	Gravel and sand
	125	62	36	1.4	0.9	1.2	Gravel and sand
	130	45	51	2.6	1.0	1.2	Gravel and sand
699-78-62	5	28	49	16.5	6.2	4.9	Cemented gravel
	10	25	61	8.5	6.1	5.6	Cemented gravel
	15	19	54	21.0	5.5	5.2	Boulders
	20	32	47	16.3	4.7	4.7	Cemented gravel
	25	21	58	16.1	5.0	5.0	Gravel
	30	29	52	14.8	4.7	4.6	Gravel
	35	28	49	17.2	6.4	4.9	Gravel
	40	32	47	15.4	5.3	4.6	Gravel
	45	25	50	17.0	7.3	4.1	Cemented gravel
	50	25	52	16.0	7.0	3.4	Cemented gravel
	55	14	61	17.6	8.1	3.2	Cemented gravel
	60	21	60	14.1	5.4	2.2	Cemented gravel
	65	16	61	16.7	6.6	2.3	Cemented gravel
	70	12	68	14.8	5.1	2.0	Gravel and clay

Table 2-6. Cation Exchange Capacities. (sheet 3 of 3)

Well number	Depth of sample (ft below surface)	Grain size				Cation exchange capacity (meq/100 g)	Lithology (from driller's log)
		Material above 2 mm (%)	Sand (%)	Silt (%)	Clay (%)		
Wells in the B/C Area							
199-B3-2	10	39.9	71.6	22.4	6.0	10.4	Boulders, gravel, and silt
	25	23.6	72.7	22.1	5.2	8.5	Boulders, gravel, and silt
	45	43.1	85.8	12.3	1.9	4.3	Coarse gravel, little sand and silt
	65	29.0	70.4	25	4.6	4.5	Coarse gravel, little sand and silt
	80	9.1	92.7	7.3	0	3.1	Sandy gravel and gravelly sand
	100	49.3	95.8	3.4	0.93	5.1	Sandy gravel and gravelly sand
	115	38.2	85.9	11.0	3.1	5.7	Sandy gravel and gravelly sand
	135	39.5	92.6	6.7	0.7	4.8	Sandy gravel and gravelly sand
	155	11.5	65.7	23.8	10.5	20.1	Sand and silt with some gravel, clay, and caliche
	175	0	17.6	29.8	52.6	48.9	Sand and silt with some gravel, clay, and caliche
	190	29.7	80.3	13.3	6.4	14.1	Sand and silt with some gravel, clay, and caliche
	210	0	58.6	29.3	12.1	23.9	Sand and silt with some gravel, clay, and caliche
	230	0	63.3	30.9	5.8	12.8	Sand and silt with some gravel, clay, and caliche
	250	0	57.7	33.2	9	17.9	Sand and silt with some gravel, clay, and caliche
	270	55.1	85.3	12.2	2.5	6.2	Sandy gravel
	290	57.4	83.1	12.9	4.0	6.2	Sandy gravel
	310	0	68.0	27.9	4.1	14.1	Layers of sand, silt, and clay with some gravel
	325	71.0	86.2	11.9	1.9	6.8	Sandy gravel
	340	68.5	92.2	5.6	2.2	5.4	Sandy gravel
	370	11.7	93.0	6.8	0.2	4.4	Sand, silt, and clay with some gravel and caliche
	380	2.1	66.4	8.2	8.5	10.0	Sand, silt, and clay with some gravel and caliche
	395	0	12.5	57.5	30.0	35.8	Sand, silt, and clay with some gravel and caliche
	415	0	8.8	62.0	28.8	24.2	Sand, silt, and clay with some gravel and caliche
	435	0	6.7	62.5	30.8	35.2	Sand, silt, and clay with some gravel and caliche
	450	0	39.8	21.8	18.4	22.3	Sand, silt, and clay with some gravel and caliche
	470	11.6	12.4	58.5	29.1	38.2	Blue clay
	495	0	15.7	57.9	26.4	21.2	Blue clay
	515	0	11.0	62.5	26.5	25.8	Blue clay
	535	0	1.8	65.8	32.4	23.7	Blue clay
	560	0	17.6	63.1	19.3	32.1	Blue clay
	580	0	11.2	52.8	36.0	39.5	Blue clay
	600	38.0	69.5	20.2	10.3	19.0	Clay, sand, and gravel
	620	0	71.0	19.7	9.3	19.0	Clay, sand, and gravel
	640	19.4	59.6	21.6	18.8	32.9	Clay, sand, and gravel
	655	0	4.0	29.3	66.5	21.2	Clay, sand, and gravel
	505(?)	0	12.0	65.3	22.7	--	Clay, sand, and gravel

Sources: Bensen et al. 1963 and McHenry 1957.

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Table 2-7. Aquifer Properties for Hydrologic Units in the 100-K Area.

<u>Hydraulic Conductivities</u>		
Ringold unit 1:	Producing layer A	20 to 6,000 ft/d[a]
Ringold unit 2:	Confining layers B and C, Confined aquifer B	0.11 to 10 ft/d[b]
Ringold unit 3:	Confined aquifer C	0.01 to 1,000 ft/d[a]
Elephant Mountain Basalt		10^{3} to 10^{-9} ft/d[c]
Rattlesnake Ridge Interbed		0.1 to 100 ft/d[d]
<u>Storage Coefficients</u>		
Ringold		0.0002 to 0.05[a]
Saddle Mountains Basalt Interbeds		10^{-3} to 10^{-4}[e]

[a]DOE 1988 and Schalla et al. 1988.
[b]DOE 1988.
[c]Based on reported value for permeable zone of Elephant Mountain Basalt (Gephart et al. 1979) and flow interiors of the Wanapum and Grande Ronde Basalts (Strait and Mercer 1987).
[d]Gephart et al. 1979.
[e]DOE-RL 1982.

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Table 2-8. Ground Water Elevations in Selected 100-K Area Monitoring Wells. (sheet 1 of 5)

Well	Casing elevation (ft, msl)	Date measured	Ground water elevation (ft, msl)
K-11	467.66	5/10/61	398.06
		6/16/61	404.21
		12/11/61	398.13
		2/21/62	398.86
		7/5/62	402.96
		12/27/62	399.72
		7/19/63	406.96
		12/10/63	401.04
		7/21/64	407.29
		12/18/64	400.99
		8/17/65	407.22
		9/21/65	404.74
		10/19/65	403.71
		12/27/65	407.22
		3/3/66	406.38
		4/13/66	404.05
		5/18/66	405.89
		7/27/66	408.82
		10/20/6	405.62
		12/29/66	406.68
		4/7/67	410.49
		6/19/67	418.90
		10/12/67	413.94
		4/23/69	407.12
		5/6/70	401.14
		9/10/71	396.27
		3/10/72	394.92
		10/2/72	396.72
		7/13/72	400.79
		1/4/73	393.83
		4/11/73	393.51
		7/6/73	392.24
		8/13/73	392.90
		8/27/73	392.32
		9/12/73	392.04
		9/28/73	391.70
		10/11/73	391.78
		10/18/74	393.79

Table 2-8. Ground Water Elevations in Selected 100-K Area Monitoring Wells. (sheet 2 of 5)

Well	Casing elevation (ft, msl)	Date measured	Ground water elevation (ft, msl)
K-11 (cont.)		1/8/75	393.04
		4/14/75	393.88
		7/7/75	394.72
		12/3/75	394.06
		6/15/76	396.76
		12/8/76	394.60
		7/1/77	392.38
		12/7/77	390.45
		6/1/78	394.10
		12/1/78	392.89
		12/1/79	393.18
		6/1/80	395.48
		12/1/80	392.64
		6/1/81	396.10
		12/1/81	393.08
		6/1/82	396.02
		12/1/82	393.01
		6/1/83	395.90
		12/1/83	394.22
		6/1/84	314.45
		12/1/84	393.75
		6/21/85	394.65
		1/3/86	393.57
		12/16/86	393.92
		3/25/87	393.20
		4/23/87	393.39
		7/28/87	393.38
		12/17/87	393.53
		12/6/88	393.80
		2/16/89	394.44
		6/8/89	395.21
K-20	422.57	12/30/57	415.17
		12/27/62	417.87
		12/10/63	418.96
		7/22/64	418.90
		12/18/64	417.84
		7/16/65	403.83
		8/17/65	406.44
		9/21/65	411.06
		10/19/65	418.02

Table 2-8. Ground Water Elevations in Selected 100-K Area Monitoring Wells.
(sheet 3 of 5)

Well	Casing elevation (ft, msl)	Date measured	Ground water elevation (ft, msl)
K-20 (cont.)		12/27/65	404.64
		3/3/66	406.49
		4/13/66	398.35
		5/18/66	415.51
		7/27/66	405.63
		10/19/66	415.77
		12/29/66	405.99
		10/12/67	417.48
		10/19/67	416.87
		3/5/68	413.50
		6/4/68	409.94
		4/23/69	414.69
		9/10/71	389.83
		3/10/72	389.22
		7/13/72	396.59
		10/2/72	389.34
		1/4/73	388.59
		4/11/73	388.45
		7/6/73	385.98
		8/13/73	387.91
		8/27/73	386.93
		9/12/73	386.67
		9/28/73	386.17
		10/11/73	386.62
		5/6/74	391.76
		7/23/74	392.86
		10/18/74	389.10
		1/8/75	387.90
		4/14/75	389.03
		4/18/76	389.03
		3/18/87	386.75
		3/25/87	386.91
		4/23/87	387.37
		7/28/87	386.99
		2/16/89	388.75
6-72-73	482.57	12/4/61	403.00
		12/11/61	402.97
		2/21/62	402.89
		7/2/62	402.61

Table 2-8. Ground Water Elevations in Selected 100-K Area Monitoring Wells.
(sheet 4 of 5)

Well	Casing elevation (ft, msl)	Date measured	Ground water elevation (ft, msl)
6-72-73 (cont.)		12/27/62	401.43
		7/22/63	403.21
		12/6/63	399.24
		7/14/64	403.92
		12/29/64	403.26
		7/16/65	406.57
		8/17/65	406.09
		9/21/65	405.13
		10/19/65	404.52
		12/27/65	404.09
		3/3/66	403.35
		4/13/66	402.28
		5/18/66	402.26
		7/27/66	404.49
		10/20/66	402.75
		12/29/66	402.14
		4/7/67	401.66
		6/19/67	403.71
		9/25/67	404.39
		9/27/67	404.35
		10/12/67	404.09
		10/19/67	404.02
		10/27/67	403.94
		11/9/67	404.04
		11/20/67	404.38
		11/27/67	404.27
		12/4/67	404.81
		12/11/67	406.54
		3/11/68	410.83
		3/18/68	411.12
		4/23/69	404.95
		11/12/69	400.38
		5/6/70	398.66
		9/14/71	400.86
		3/10/72	398.24
		7/13/72	402.63
		10/2/72	400.79
		1/4/73	400.79
		4/11/73	398.52

Table 2-8. Ground Water Elevations in Selected 100-K Area Monitoring Wells. (sheet 5 of 5)

Well	Casing elevation (ft, msl)	Date measured	Ground water elevation (ft, msl)
6-72-73 (cont.)		7/6/73	398.14
		8/13/73	397.30
		8/27/73	397.15
		9/12/73	397.03
		9/28/73	396.87
		10/11/73	396.75
		1/17/74	396.72
		4/21/74	398.09
		7/22/74	400.21
		10/18/74	398.47
		1/8/75	397.34
		4/14/75	397.58
		7/7/75	399.19
		12/3/75	396.51
		6/15/76	398.67
		12/15/76	397.78
		7/1/77	396.16
		12/7/77	395.53
		6/1/78	397.39
		12/1/78	394.68
		12/1/79	395.78
		6/1/80	396.90
		12/1/80	395.82
		6/1/81	397.72
		12/1/81	396.87
		6/1/82	398.57
		12/1/82	400.23
		6/1/83	398.82
		12/1/83	397.14
		6/1/84	398.39
		12/1/84	397.32
		6/13/85	398.34
		1/3/86	397.33
		12/10/86	397.93
		12/11/87	397.44
		6/24/88	397.75
		12/6/88	397.52
		5/22/89	398.23
		6/9/89	398.53

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Table 2-9. Washington State List of Endangered Flora Species Having the Potential to be Found on the Hanford Site.

Endangered Vascular Plants	
Persistant sepal yellowcress (*Rorippa columbiae*):	Known to have a scattered distribution because of specialized habitat requirements or habitat loss; generally occurs in moist to marshy places and is known to inhabit the wetted shoreline of the Hanford Reach of the Columbia River in Benton County.
Threatened Vascular Plants	
Columbia milk-vetch (*Astragalus columbianus*):	Locally endemic to the area in the immediate vicinity of Priest Rapids Dam, including a portion of Benton County; could potentially occur along the Columbia River in the northwestern portion of the Hanford Site.
Eatonella (*Eatonella nivea*):	Known to occur along the Columbia River in Grant County; could potentially occur along the river in the northern portion of the Hanford Site.
Hoover's desert parsley (*Lomatium tuberosum*):	Locally endemic to south-central Washington, including Benton County; known to inhabit rocky hillsides.

Sources: DOE 1987; Hitchcock and Cronquist 1973; Department of Natural Resources 1987; Department of Wildlife 1987.

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Table 2-10. Washington State List of Endangered and Threatened Fauna Species Having the Potential to be Found on the Hanford Site. (sheet 1 of 2)

<u>Endangered Birds</u>

Aleutian Canada goose (*Branta canadensis leucopareia*):	Nests in the Aleutian Islands of Alaska and winters in California; has been occasionally sighted, as a migrant, in Benton County; a potential seasonal user of the Columbia River valley, feeding on grasses, sedges, and berries.
American white pelican (*Pelecanus erythrorhynchus*):	Winters along the southern pacific coast and the gulf coast and nests in northern prairie and intermountain lakes; no longer nests in Washington; migrates through eastern Washington; flocks are common in the Columbia Basin during the summer; known to occasionally winter on the Columbia River, foraging on fish, amphibians, and crustaceans and roosting on islands.
Peregrine falcon (*Falco peregrinus*):	Breeds and winters in eastern Washington, inhabiting open marshes, river shorelines, wide meadows and farmlands; nests on undisturbed cliff faces; an erratic visitor at the Hanford Site, feeding on songbirds, shorebirds, and waterfowl.
Sandhill crane (*Grus canadensis*):	Inhabits open prairies, grainfields, shallow lakes, marshes, and ponds, nesting in drier grassy and marshy areas; common migrant during the spring and fall in Washington; some known and suspected nesting sites in eastern Washington; unlikely visitor at the Hanford Site.
Upland sandpiper (*Bartramia longicauda*):	Inhabits ungrazed and lightly grazed prairies, upland meadows, and fields that are usually located near lakes or rivers; breeds in the northern and central portions of North America and winters in South America; uncommon in eastern Washington; a potential migratory visitor at the Hanford Site, feeding on insects, worms, and some vegetation.

Table 2-10. Washington State List of Endangered and Threatened Fauna Species Having the Potential to be Found on the Hanford Site. (sheet 2 of 2)

	<u>Endangered Birds</u> (cont'd)
Western snowy plover (*Charadrius alexandrus*):	A coastal species rarely observed in eastern Washington.
	<u>Threatened Birds</u>
Bald eagle (*Haliaeetus leucocephalus*):	A regular winter visitor to the Columbia River, feeding on spawning salmon and perhaps waterfowl and small mammals; roosting areas are known to exist in the 100 Areas of the Hanford Site (roost sites and winter feeding areas constitute critical habitats for this species).
Ferruginous hawk (*Buteo regalis*):	Inhabits open prairies and sagebrush plains, usually with rocky outcrops or scattered trees, located well away from human disturbance; known to nest in Benton and Franklin counties, with Franklin County possessing the majority of the nests within Washington; known to nest in the Hanford Site on the Arid Lands Ecology Reserve; rarely winters in Washington; known to occasionally forage on small mammals, birds, and reptiles in sagebrush plains on the Hanford Site.
	<u>Threatened Mammals</u>
Pygmy rabbit (*Sylvilagus idahoensis*):	Inhabits undisturbed areas of sagebrush with soils soft enough to dig burrows; once known to exist on the Hanford Site near springs in the Snively Basin west of the 200 Area plateau in the Rattlesnake Hills.

Sources: DOE 1987; Hitchcock and Cronquist 1973; Department of Natural Resources 1987; Department of Wildlife 1987.

3.0 INITIAL EVALUATION

This chapter begins with a discussion of the known and suspected contamination sources in the environmental media in the 100-K Area. An evaluation of these data is presented and, together with other information, is used to develop a site conceptual model for contaminant transport. Potential ARARs are evaluated and presented for comparison with existing contaminant levels. Preliminary remedial action objectives, general response actions, and remedial technologies and alternatives are presented. The preliminary remedial action alternatives are based on the currently available site and contaminant information, site conceptual model, preliminary risk assessment, and potential ARARs.

3.1 KNOWN AND SUSPECTED CONTAMINATION

The following sections present known and suspected contaminant sources and current knowledge about the extent of the environmental contamination in 100-KR-1, 100-KR-2, 100-KR-3, and 100-KR-4 operable units. Previous sampling in the 100-K Area focused on locating and quantifying radioactive species. Some historical data are available on the use of inorganic chemicals, but characterization efforts have generally not included analyses for nonradioactive inorganic species. Virtually no historical information on sampling and analytical data are available on the use of, or contamination by, organic species. A goal of this RI will be to gather data on the distribution and concentration of radioactive species and nonradioactive inorganic and organic species.

The 100-K Area soil and sludges were studied during 1975 and 1976 when Dorian and Richards attempted to quantify residual radionuclide contamination. Their results were published in a 1978 report (Dorian and Richards 1978), which is used as a primary reference for this work plan. The data generated for this report were used for the hazard ranking system evaluation of the Hanford Site, the Waste Information Data System (WIDS) database (WHC 1990b) maintained by Westinghouse Hanford, and this work plan.

Dorian and Richards did not evaluate all radionuclides of concern. In particular, ^{63}Ni, which is generally present at activity levels on the same order of magnitude as ^{60}Co, were reported for only some samples, and daughter product radionuclides of ^{90}Sr and ^{137}Cs, which have approximately the same activity level as the parents, were not reported at all.

3.1.1 Sites

The *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989) lists five waste sites in 100-KR-1, 15 waste sites in 100-KR-2, and 13 waste sites in 100-KR-3. The *Hanford Site Waste Management Units Report* (DOE-RL 1989) lists 12 additional contaminant sources in 100-KR-2 and six additional contaminant sources in 100-KR-3. Figure 3-1 and Table 3-1 locate and profile the waste sites and additional contaminant sources within these operable units.

The 100-KR-4 ground water operable unit covers an area that encompasses three source operable units, two of which (100-KR-2 and 100-KR-3) are scheduled for investigation later in the environmental restoration process. It has been recognized that there is a need for early identification of specific contaminant sources within these lower priority operable units that may be significant contributors to ground water contamination. To that end, a strategy is under development for streamlining the RI/FS process. The strategy provides for accelerating the decision-making process by maximizing the use of existing data and conducting near-term abatement actions in situations that represent imminent and substantial endangerment (ISE) or interim response action (IRA) cases.

Individual waste sites within the 100-KR-4 operable unit have been reviewed and evaluated to determine if the site should be included as a candidate for an ISE or IRA. In the absence of detailed information, professional judgment has been exercised. The process is, however, subjective and has not led to a quantitative ranking of the sites. Preliminary criteria have been developed which were used to determine if a waste site is potentially an ISE or IRA. Considerations used to rank individual waste sites as significant (ISE warranted), minor (IRA warranted), or insignificant (no near-term action warranted) were: (1) nature and physical state of the contaminant; (2) pathway through the ecosystem; (3) travel time through the environment; (4) distance to potential receptors; (5) volume and concentration of potential contaminants; (6) possible exposure levels; (7) protection of human health and the environment; and (8) implications of a delay in abatement actions.

The ratings were based on information contained in the WIDS and other individual information sources. Because existing information is often incomplete, not all criteria could be adequately assessed. Because of the lack of detailed information, additional considerations were often used, such as duration the site was in service; time since the site was last used; and potential to leach, by meteoric recharge, to the ground water system.

Because the main focus for the 100-KR-4 operable unit is ground water and it is the primary environmental media subject to an ISE or IRA, ground water was used as the focus during the rating process. However, it is recognized that the waste units as well as contaminants contained in the vadose zone, may represent a continual source of ground water degradation.

One critical aspect of the process that has not been developed is the definition of criteria that would trigger an immediate or near-term abatement action. For the purpose of this work plan, the process is perceived as an iterative one whereby new information gained from the RI is evaluated in a preliminary risk assessment. The risk assessment would then be used to help define action and, ultimately, cleanup criteria.

The following sections describe individual waste sources by operable unit. As discussed above, the focus of the ranking system was ground water and data are limited. Based on the limited data available the rating was indeterminate; but it appears that no waste sources are candidates for an ISE or IRA. However, wells are or will be placed downgradient of all substantial waste handling facilities contain in each of the three source operable units. Early in the RI process ground water will be tested for a broad range of contaminants in each of the wells. The results of these tests may serve to focus on contaminant sources not currently recognized as a potential ISE or IRA case.

3.1.1.1 Sources in 100-KR-1 Operable Unit. The major sources of contamination in the boundaries of 100-KR-1 operable unit are associated with the cooling water effluent system. A discussion of the cooling water circuit appears in Section 2.1.4.1.1. During normal operations, cooling water flowed in underground pipes from the reactors to the 107-K retention basins, then discharged to the Columbia River. The cooling water was contaminated with relatively low concentrations of radionuclides and hazardous chemical species, including chromium. Cooling water with elevated concentrations of radionuclides (a result of a fuel cladding failure) was generally diverted to the 116-K-2 trench and disposed of to the soil column. Adequate records of fuel cladding have not been located.

During reactor operations, contaminated sludge accumulated in the bottom of the retention basins. As an interim action, sludge was removed from the basins on at least one occasion and reportedly transferred to a burial ground located adjacent to the 107-KE retention basins. This burial ground was not designated as a waste site in the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989). This site has been numbered as site 118-K-2 for reference throughout this work plan. The following subsections discuss the known and potential contaminant sources associated with the water effluent system.

3.1.1.1.1 Waste Sites 116-KE-4 and 116-KW-3 (Retention Basins). These waste sites include the six 107-K retention basins. The 107-K retention basins are significant waste sites for the 100-K Area. Each basin was constructed with welded carbon steel plate, is 250 ft (83 m) in diameter and 20 ft (7 m) high, and mounted on reinforced-concrete foundations. Each inlet structure consists of a 72-in. (183-cm) pipe leading to an outlet chute that discharges at the bottom of the basin. The basins were used from 1955 to 1971 to retain effluent cooling water from the 105-KE and 105-KW reactors. The basins allowed for thermal cooling of circulated water and decay of short-lived isotopes before release to the Columbia River. In 1971 the basins were deactivated, pipe entrances were covered for wildlife control, walls were washed down, and approximately 2 ft (0.7 m) of dirt was placed at the bottom of each basin.

During operation, basins frequently developed leaks. Leakage rates were estimated at 10,000 to 20,000 gal/min (37,850 to 75,700 L/min). The first indications of large leaks occurred before 1965 when extensive ponding reportedly developed between the basins and the road directly to the north. To prevent ponding, 2 to 3 ft (0.7 to 1.0 m) of fill was placed in this area. Cooling water that leaked from the basins flowed over land and under the road by way of a culvert. Because the basins were less than 1,000 ft (330 m) from the shoreline, it was common occurrence for leaked effluent to reach the Columbia River. Predominant radionuclides present in the soil column as a result of cooling water leaks and waste disposal are ^{3}H, ^{60}Co, ^{63}Ni, ^{90}Sr, ^{137}Cs, ^{152}Eu, ^{154}Eu, and ^{155}Eu.

Twenty-four samples from 12 locations were collected inside the 107-KE and 107-KW basins. The locations of these samples are shown in Figure 3-2. The average Geiger-Muller (GM) tube reading was 2,000 cpm for soil samples taken along the bottom of the basin fill material. A summary of the retention basin radioactive inventories is given in Table 3-2 (Dorian and Richards 1978). Specific radionuclide concentrations for the 24 samples are given in Table 3-3.

The discharge system includes effluent lines from the 105-K reactors to the 107-K retention basins, and from the retention basins to the 1904 outfall structure, 116-K-1 crib, and 116-K-2 trench. The approximate location of the major effluent lines is shown in Figure 2-2. Exact locations are not known for several line segments. Leakage has been reported at the 150-K heat exchangers and in the valve pits.

3.1.1.1.2 Waste Site 116-K-1 (Crib). The 116-K-1 crib is an excavated rectangular percolation basin 200 by 200 ft (70 by 70 m) at the bottom, 400 by 400 ft (140 by 140 m) at the surface, and 22 ft (7 m) deep. The crib failed to percolate adequately and was replaced by a 4,000 by 50 ft (1,300 by 15 m) gravel-lined percolation trench (116-K-2). At least once, effluent overflowed one side of the crib resulting in direct discharge to the river. There is conflicting information concerning the number of times cooling water effluent was discharged to this crib.

The 116-K-1 crib and surrounding area was investigated by collecting 16 samples from 5 locations identified as A' through E' in Figure 3-3 (Dorian and Richards 1978). Radiation along the bottom of the crib averages approximately 1,000 cpm with localized contamination present up to 10,000 cpm. Specific radionuclide concentrations for the 16 samples are presented in Table 3-4.

In addition, the waste stream to the crib contained approximately 40 kg (88 lb) of sodium dichromate. Sodium dichromate was added to the cooling water process to inhibit corrosion of the circulation system.

The sides and bottom of the crib were covered with dirt and gravel in the early 1960s. A visual site inspection in 1990 showed the crib is enclosed by a cyclone fence and posted with radiation signs.

3.1.1.1.3 Waste Site 116-K-2 (Trench). The 116-K-2 trench was excavated to percolate cooling water effluent into the soil column. The trench dimensions are about 4,000 by 50 ft (1,300 by 15 m) and 20 ft (7 m) deep. The trench was constructed in 1955 to replace the 116-K-1 crib. In 1971, the sides and bottom of the trench were covered (except the influent end) with a layer of dirt and later backfilled to grade.

The area inside the 116-K-2 trench was investigated by collecting 46 samples from 14 locations in the mid-1970s (Dorian and Richards 1978) (Figure 3-3). Contamination levels measured in sample holes ranged from less than 200 to 12,000 cpm with a GM probe. Specific radionuclide concentrations for the 46 samples are presented in Table 3-5. No clear pattern exists from this data other than a general trend towards higher levels of contaminants in the shallower samples. Chemical compounds disposed of in the trench include 300,000 kg (661,000 lb) of sodium dichromate, 500 kg (1,100 lb) of copper sulfate, 10,000 kg (22,000 lb) of sulfuric acid, and 10,000 kg (22,000 lb) of sulfamic acid (Stenner et al. 1988).

3.1.1.1.4 Waste Site 116-K-3 (Outfall Structure). The 1904 outfall structure consists of a reinforced-concrete building, approximately 30 by 30 ft (10 by 10 m) and 15 ft (5 m) high, two 84-in. (213-cm) steel effluent lines and a concrete-lined emergency overflow spillway. The outfall structure collected discharge from the 107-KE basins via a 66-in. (168-cm) steel pipeline, the 107-KW basins via a 72-in. (183-cm) steel pipeline via a concrete sewer from the water treatment plant and other onsite facilities. Discharge from the outfall structure was conveyed to the center of the Columbia River through two 84-in. (213-cm) steel pipes. The emergency overflow spillway conveyed water from the outfall structure directly to the edge of the river. The concrete in the channel has been removed and disposed of. Radiological surveys are routinely performed. These data will be compiled and reviewed during the source data compilation task.

3.1.1.2 Sources in Operable Unit 100-KR-2. The waste sources in the 100-KR-2 operable unit received solid and liquid wastes generated by reactor operations.

As described in detail in Section 2.1.4, treated Columbia River water was used for a variety of purposes including the cooling of spent fuel in two fuel storage basins. Support facilities, such as reactor support water recirculation and research and development buildings, also generated liquid wastes that were managed via individual cribs.

Facilities within the 100-KR-2 operable unit also generated a wide variety of solid and semisolid wastes. The main radioactive solid waste burial ground for the 100-K Area and another burial ground used intermittently for disposal of sludges from the 107-K retention basins are also within the 100-KR-2 operable unit.

3.1.1.2.1 Waste Sites 116-KE-1 and 116-KW-1 (Cribs). The 116-K cribs received condensate and other small volume liquid wastes from the 115-KE/KW reactor gas recirculation building. The cribs measure 6 by 6 ft (2 by 2 m) at the bottom, 40 by 40 ft (7 by 7 m) at the top, and are 26 ft (9 m) deep. The 116-KW crib has an estimated radioactive inventory of 240 Ci; almost entirely from ^{3}H and ^{14}C, which are low energy beta emitters. Specific radionuclide concentrations are shown in Table 3-6. Ground water will be tested for a broad spectrum of chemicals from downgradient wells K10, K11, and K41 (proposed) for 116-KW-1, and wells K16, K29, and K30 for 116-KE-1.

3.1.1.2.2 Waste Site 116-KE-2 (Crib). This waste site is associated with the water studies recirculation building (1706 KER). The 116-KE-2 crib measures 16 by 16 ft (5 by 5 m) at the bottom and is 32 ft (11 m) deep. The crib received liquid wastes from cleanup columns in the 1706-KER loop during the period from 1955 to 1971. A GM reading of 15,000 cpm was detected in a sample at 42 ft (14 m) below grade. The crib contains an estimated radioactive inventory of 38 Ci, of which 33 Ci are attributed to ^{60}Co and the remaining primarily to ^{90}Sr (Dorian and Richards 1978). Specific radionuclide concentrations for the 116-KE-2 crib are presented in Table 3-6. There are several downgradient wells (K16, K27, K28, K29, K30) that will be used to test ground water quality from this area.

3.1.1.2.3 Waste Sites 116-KE-3 and 116-KW-2 (Fuel Storage Basin Subdrainage Reverse Wells). The 116-KE-3 and the 116-KW-2 waste sites received subdrainage from the 105-K fuel storage basins. These potentially contaminated reverse wells are about 75 ft (24 m) north of the 105-KE and 105-KW reactor buildings. Each is a 20-ft (7-m) dia drainfield made up of 8-in. (20-cm) perforated steel pipe embedded in gravel at a depth of about 29 ft (9 m). An 8-in. (20-cm) steel well casing extends downward from this to a point 10 ft (3 m) below mean water table.

3.1.1.2.4 Waste Site 118-K-1 (Burial Ground). The 118-K-1 burial ground was the primary solid waste disposal site for the 100-K Area. The burial ground measures 1,200 by 600 ft (400 by 200 m) and is 20 ft (7 m) deep. The burial ground contains many pits and trenches used to contain disposed material. Material present in the solid waste burial ground includes aluminum spacers, lead-cadmium metal, boron splines, ^{14}C sources, process tubes, lead (e.g., bricks and sheets), cadmium sheets, thermocouple wire, soft waste (plastic, and paper for example), and miscellaneous waste (reactor tools, and safety rods, for example) (Miller and Wahlen 1987). As a result of the nature of the waste at this site it is not considered an ISE or IRA candidate. A well is proposed directly downgradient (K41) that will test the nature of the ground water in this area.

3.1.1.2.5 Waste Sites 130-K-1, 130-K-2, 130-KE-1, 130-KE-2, 130-KW-1, 130-KW-2 (Fuel Storage Tanks). These waste sites are associated with diesel fuel, fuel oil, or petroleum storage. These tanks are no longer in use and have been emptied. The 130-K-1 and 130-K-2 fuel tanks were removed from the site in 1989. There are no analytical data on these sites, but it has been reported that the soil by the tanks may be contaminated from spillage. Although these storage tanks may represent a substantial source of contamination, no leaks were reported. Therefore, the sites are not currently considered candidates for an ISE or IRA. However, testing for organic chemicals in ground water early in the RI process may focus attention on one or more of these storage tanks as contributors to environmental degradation.

3.1.1.2.6 Waste Sites 1607-K-4 and 1607-K-6 (Septic Tanks). The 1607-K-4 waste site received sanitary sewage from the 1704-K office building and the 1717-K maintenance shop. The 1607-K-6 waste site received sanitary sewage from the 105-KW reactor building, 115-KW gas recirculation building and the 165-KW powerhouse. Both of these septic systems are still in use. The waste category is nonhazardous and nonradioactive. Although the septic systems are considered sources of nonhazardous and nonradioactive wastes, they may be sources of either or both types of contamination.

3.1.1.2.7 Waste Site UN-100-K-1 (105-KE Fuel Storage Basin Leak). During modification of the 105-KE fuel storage basin for installing the recirculating cooling system in 1974, a 4-gal/min (15-L/min) leak was measured. By early 1977, the leak volume had increased to 13.5 gal/min (51 L/min). The leakage was stabilized at about 8 gal/min (30 L/min) by raising the basin water temperature and thus partially closing cracks in the basin floor. Eventually an ebypansion joint in the floor of the basin discharge chute was isolated by watertight dams, which reduced leakage to near zero. In 1980, drawdown testing showed the leakage to be 3 gal/h (11 L/m).

The 2-in. (5-cm) asphalt membrane beneath the basin collected most of the leakage. The asphalt membrane does not extend beneath the 105-KE reactor pickup chute; therefore, leakage from that area could escape to the soil column. Table 3-7 shows the radionuclide concentrations in the 105-KE fuel storage basin water according to Dorian and Richards (1978). Table 3-8 is an inventory of radionuclides in the soil near the 105-KE fuel storage basin, also after Dorian and Richards (1978).

3.1.1.2.8 Waste Source 116-KE-5 and 116-KW-4 (Heat Exchangers). The 116-KE-5 and the 116-KW-4 heat exchangers transferred heat from the reactor cooling water effluent by means of an ethylene glycol system. The heat was piped to the K-Area buildings for space heating. No data have been reported on the radionuclide concentrations at these sources.

3.1.1.2.9 Waste Source 116-KE-6(A) Through 116-KE-6(D). These four waste sources are storage tanks. The only documentation available shows that their waste category is mixed waste and that the tanks were installed in 1986 and are presently in use.

3.1.1.2.10 Waste Sources 118-KE-1 and 118-KW-1 (Reactor Buildings). Each of the two 110-K Area reactor buildings include a reactor block, an irradiated fuel storage basin, ventilation systems, and work areas.

The 105-KE and 105-KW reactor blocks each consist of a graphite moderator stack encased in cast-iron thermal shielding and a heavy aggregate concrete biological shield, process tubes, and safety and control systems. Each reactor block weighs approximately 11,000 tons and measures 44 ft (13.4 m) from front to rear, 53 ft (16.2 m) from side to side and 50 ft (15.2 m) from top to bottom. The reactor was sealed within a helium-nitrogen gas atmosphere circulated from the respective 115-K facility. The gas fuel elements and control systems were removed at the time of deactivation. Estimated 1985 radionuclide inventories of the 105-KE and 105-KW reactors are shown in Table 3-9 and Table 3-10, respectively.

The 105-KE and 105-KW fuel storage basins each have a surface area of approximately 10,000 ft^2 (930 m^2), a depth of 20 ft (7 m) and a volume of about 200,000 ft^3 (5,700 m^3).

These basins originally provided shielding and cooling for the irradiated fuel during reactor operation. Following shutdown of the 105-KE and 105-KW reactors, both fuel storage basins were cleaned and modified for the storage of irradiated fuel from the 100-N Area. In 1974 and 1975, the fuel storage basins were modified by adding a recirculating cooling system in part consisting of the 150-KE and 150-KW heat exchangers.

Storage of N reactor irradiated fuel began in the 105-KE storage basin before use of sealed canister packaging for prevention of contact between the fuel and the cooling water. All N reactor fuel stored in the 105-KW storage basin has been packaged in the sealed canisters. Consequently, there may be a large difference in the level of radioactive contamination between the two storage basin facilities.

The 105-KW fuel storage basin sediments were investigated in April 1975 by Dorian and Richards (1978). Radionuclide concentrations in the sediments are shown in Table 3-11.

In 1985, sludge samples were obtained from the 105-KE fuel storage basin (DeMers 1985). The results of the sample analysis are included in Table 3-12. A discussion of the UN-100-K-1 105-KE fuel storage basin leak is given in Section 3.1.1.2.7.

3.1.1.2.11 Waste Source 118-KE-2 and 118-KW-2 (Thimble Caves). These waste sources are the thimble caves which were used for storing radioactive rod tips removed from the reactor. The sites are not considered to represent a substantial threat to human health or the environment.

3.1.1.2.12 Waste Source 132-KE-1 and 132-KW-1 (Ventilation Stacks). These waste sources are the ventilation stacks for the reactor air filter system. The top 125 ft (42 m) of these stacks were demolished after deactivation. The rubble was placed in the bottom of the stack.

3.1.1.2.13 118-K-2 Burial Ground. This burial ground was reportedly used to dispose of radioactive sludge from the 107-K retention basins. No additional information is currently available on this site.

3.1.1.2.14 118-K-3 Filter Crib. This crib was reportedly used to dispose of liquid wastes from research done in the 1706-KE building. The material disposed of here has been reported as nonradioactive. No additional information has been found to quantify the waste stream to the crib.

3.1.1.2.15 French Drain at SE Corner of 1706-KE. A 4-ft (1.2-m) dia gravel-filled drain provides overflow for the 1706 laboratory sodium hydroxide and sulfuric acid tanks, both of which continue to be used.

3.1.1.2.16 Solid Waste Dump and Burn Site. Located a quarter-mile west of 100-K western boundary (along the banks of the old Hanford Site irrigation canal), this burning ground is fenced off and marked as an asbestos hazard area. Surface burning of chemicals and miscellaneous waste occurred here. (This site served more recently as an asbestos dump).

3.1.1.2.17 Ethylene Glycol Tanks. These large underground tanks are located at 165 KE and KW, two at each site. Glycol was used for the 105 building space heaters.

3.1.1.2.18 French Drains at 165-KE and -KW. A french drain is located a little west of each of the ethylene glycol tanks. Each is a 4-ft (1.2-m) dia, gravel-filled drain.

3.1.1.2.19 French Drain West of 166-KW Oil Tank. A 4-ft (1.2-m) dia gravel-filled french drain is located 100 ft (30 m) west of, and across the street from, the 166-KW oil tank facility.

3.1.1.2.20 Experimental Fish Tanks. The Pacific Northwest Laboratory (PNL) conducted fish development experiments in reactor effluent waters in the early years of reactor operation at the facility marked "Experimental Radiation Exposure" on Figure 2-2.

3.1.1.2.21 Reactor Building Process Drainage System Collection Boxes. These facilities served as collection boxes for reactor building sumps and drains. Waste water from the reactor sumps was collected in these boxes and pumped from there either to the Columbia River or the 166-K-2 trench.

3.1.1.2.22 Reactor Building Sub-Basin Drainage Catch Tank Silo. A sub-basin catch tank and pump gallery exists in a 35-ft (10-m) deep concrete and steel silo structure located about 70 ft (21 m) north of 105-KW and 105-KE reactor buildings. A 20-ft (6-m) dia tile drain field runs north from each.

3.1.1.2.23 105-KE and KW Waste Storage Tank. This 9-ft-dia by 40 ft PVC-lined steel tank is located 24 ft (7 m) north of the 105-KE and 105-KW reactor buildings. Designed for waste water storage the tank reportedly was never used.

3.1.1.2.24 105-KE and KW C Sump. A concrete sump box exists 5 ft (1.5 m) north of the 105-KE and 105-KW reactor buildings north wall. Each is 7.5 ft (2 m) by 12 ft (4 m) deep designed to collect reactor basin sump draining and overflow water, each is equipped with pumps to return water to the 105 building retention basin. Small quantities of effluents, if any, would have passed through these sumps. This closed-loop system was installed after reactor shutdown and conversion of the storage basins for 100-N fuel storage to replace earlier effluent handling systems.

3.1.1.2.25 155-K Gas Recirculation Building Dry Wells. A 'drain condensate disposal system' dry well exists about 50 ft (15 m) north of 115-KW and 115-KE gas recirculation buildings. Buried about 17-ft (5 m) deep, each well is about 10-ft (3 m) in diameter and uses gravel as a dispersant.

3.1.1.3 Sources in Operable Unit 100-KR-3. The major sources of contamination within the boundaries of operable unit 100-KR-3 are associated with the water treatment facilities. Individual waste sites and structures contained within the 100-KR-3 operable unit boundary are described in the following sections.

3.1.1.3.1 Waste Sites 120-KE-1, 120-KE-2, 120-KE-3, 120-KW-1, and 120-KW-2 (Percolation Basins). These reverse wells, french drains and percolation trenches were used to dispose of sulfuric acid sludge from the sulfuric acid storage tanks. Stenner et al. (1988) report that the sulfuric acid was contaminated with mercury used in the acid manufacturing process and that about 91 lb (200 kg) of mercury was disposed of in each waste site with the exception of 120-KE-3 where 318 lb (700 kg) of mercury was disposed. Dorian (1985) reports that the mercury contaminated sludge was later removed from the percolation basins. It should be noted that Stenner et al. (1988) used a different numbering system to identify these waste sites; this numbering system substituted a number 100 for the number 120 (e.g., 120-KE-1 equals 100-KE-1, etc.).

3.1.1.3.2 Waste Site 120-KE-6 and 120-KW-5 (Sodium Dichromate Storage Tanks). These waste sites are two sodium dichromate storage tanks. These tanks were removed in 1970. There has been reported evidence of residual dichromate in the soil adjacent to these tanks.

3.1.1.3.3 Waste Site 128-K-1 (Burning Pit). The burning pit was used for the disposal of nonradioactive combustible waste such as paint, office material, and chemical solvents. There have been no data reported on contamination in this area.

3.1.1.3.4 Waste Site 130-K-3 (Fuel Storage Tanks). These two 17,000-gal (64,000-L) fuel storage tanks have been drained. No data have been reported on contamination of this area.

3.1.1.3.5 Waste Sites 1607-K-1, 1607-K-2, 1607-K-3 and 1607-K-5 (Septic Tanks). The 1607 septic tanks received sanitary sewage from the staffed facilities for the 100-K Area. These septic systems are still in use with the exception of 1607-K-3 associated with the 183-KW water treatment facility. The waste category is nonhazardous and nonradioactive. Wells placed immediately downgradient will test for contributions to ground water degradation from these tanks.

3.1.1.3.6 Waste Source 120-KE-4, 120-KE-5, 120-KW-3 and 120-KW-4 (Sulfuric Acid Storage Tanks). These waste sources are four 10,000-gal (38,000-L) sulfuric acid storage tanks. The tanks have been drained and neutralized. The 120-KE-4 and 120-KW-3 tanks leaked through the supply pipe to the respective 183.1 water treatment building. No data are available on the amount of leakage. Wells placed immediately downgradient will test for contributions to ground water degradation from these tanks (K36 and K37).

3.1.1.3.7 Waste Source 126-KE-2 and 126-KE-3 (Alum Storage Tanks). These waste sources are two 180,000-gal (680,000-L) tanks used to store liquid alum. Currently one tank is empty and the other is being used to store alum for treating river water in the water treatment facility.

3.1.1.3.8 Brine Pits. These are located immediately north of the terminus of the railroad spur that passes the south end of 183.1-KE and KW buildings. They are very near waste unit 120-KE-2, a french drain. Each is a concrete brine retention basin, perhaps 10 by 20 by 20 ft (3 by 6 by 6 m), entirely below grade (each has a wooden hatch). Salt was offloaded from railcars and mixed with water in the basin. The resulting brine was pumped to the 183 buildings for use in water treatment.

3.1.2 Soil

3.1.2.1 Background Soil Quality. There are no operable unit-specific background soil data available for the 100-K Area. However, surface soil samples are collected periodically at a number of locations both on and off the Hanford Site as part of the Hanford Environmental Monitoring Program. Onsite samples are collected at locations adjacent to major operating facilities, while offsite samples are collected around the site perimeter, primarily in a upwind direction. Sample locations are shown in Figure 3-4.

Because of their proximity to operating facilities, onsite samples cannot be regarded as providing an adequate background concentration reference point. Data from both onsite and offsite samples collected from 1982 through 1987 are presented in Table 3-13.

3.1.2.2 Soil Contamination. No soil sampling stations are located in the 100-K Area as part of the Hanford environmental monitoring program. However, soil sampling has been performed in the area under other programs.

Soil sampling was performed as part of the 1975-1976 radiological assessment of the 100 Areas (Dorian and Richards 1978). The primary contaminants measured in that study and discussed below are ^{3}H, ^{60}Co, ^{90}Sr, ^{137}Cs, ^{152}Eu, ^{154}Eu, ^{155}Eu, and $^{239/240}Pu$.

3.1.2.2.1 Soil Contamination in 100-KR-1 Operable Unit. Radionuclide levels in soil outside, but associated with, engineered waste units in the 100-KR-1 operable unit were reported by Dorian and Richards in 1978. This section discusses the results of this and other studies.

Soils outside the 107-K retention basins but encompassed by waste sites 116-KE-4 and 116-KW-3 were sampled from November through December 1975. Soils were investigated by collecting 41 discrete samples from 29 test holes. Samples were generally collected at the surface and from 5 to 25 ft (1.7 to 8 m) below the surface. Soil contamination in the area surrounding the retention basins has direct GM readings from 500 to 1,500 cpm. Specific radionuclide concentrations for the 41 soil samples are given in Table 3-14. The 107-KE and 107-KW basin vicinities have total radionuclide inventories of 6.2 and 3.9 Ci, respectively. Over 80% of the radionuclide inventory of the 107-KE and 107-KW basin areas is contained in contaminated soils adjacent to the basins.

The highest soil contaminant concentrations are adjacent to tank 107-KW-C and in 116-KE-4, at or near the surface [0 to 1 ft (0 to 0.3 m)], and approximately 50 ft (15 m) from the nearest tank. The remaining soil samples in 116-KW-3 and 116-KE-4 showed lower contaminant concentrations.

The soils affected by 116-K-1 crib and 116-K-2 trench were sampled from June through August 1975. The waste sites were investigated by collecting 91 discrete samples from 35 locations. A summary of the distribution of radionuclide inventories in and near the crib and trench appears in Table 3-15.

The area outside the effluent trench was investigated with 29 samples from 17 locations. Surface contamination [0 to 2 ft (0 to 0.7 m)] was identified approximately 150 ft (50 m) north of the trench in a former washout area. Surface contamination in these washout areas had direct GM readings from 500 to 3,000 cpm. In 1977, this contamination was covered with a few feet of soil and gravel. Specific radionuclide concentrations for the 29 samples are presented in Table 3-16.

Samples of surface soil were collected in the 100-K Area for the *1987 Environmental Surveillance Annual Report* (WHC 1987) prepared by Westinghouse Hanford. The 116-K-1 crib and 116-K-2 trench areas were investigated with five soil samples. Concentrations of radionuclides in the five soil samples are given in Table 3-17. Very low concentrations were found at the five sample sites for all the measured contaminants.

3.1.2.2.2 Soil Contamination in the 100-KR-2 Operable Unit. There are reported to have been soil samples taken near the 130-K-1 and 130-K-2 waste sites in 1989. However, no analytical results have yet been located. There has been no other soil sampling reported within the 100-KR-2 operable unit boundaries.

3.1.2.2.3 Soil Contamination in the 100-KR-3 Operable Unit. Leaks in the 120-KE-4 and 120-KW-3 sulfuric acid storage tanks have been reported, but no soil sampling data are available. There has been no other soil sampling reported within the 100-KR-3 operable unit boundaries.

3.1.3 Ground Water Quality

To date, collection of ground water quality data at the 100-K Area has not been comprehensive. Most of the data come from closely grouped wells installed for a specific purpose, for instance wells K27, K28, K29, and K30 are located around the 105-KE fuel storage basin. However, there are sufficient data for preliminary water quality assessment and identification of some of the hazards that may be encountered during well installation, sampling, and testing.

3.1.3.1 Background Ground Water Quality. Ground water in the unconfined aquifer of the Hanford Site is characterized as calcium bicarbonate dominant (Evans et al. 1989). Primary inorganic constituents include calcium, bicarbonate, sulfate, silica, sodium, chloride, magnesium, and potassium. Secondary constituents such as ammonia, barium, fluoride, manganese, and strontium occur in trace amounts (<1,000 ppb). The natural ground water has moderate total hardness (~120,000 ppb) and moderate total dissolved solids content (~250,000 ppb). Table 3-18 shows background concentrations for selected constituents in Hanford Site ground water. These background concentrations have been estimated from ground water samples collected in areas judged to be unaffected by Hanford Site operations (Evans et al. 1989). The analyses used to calculate background concentrations were part of the Hanford Site-Wide Ground Water Monitoring Project.

Background concentrations unique to the 100-K Area have not yet been determined. Initially, it can be assumed that background concentrations are similar to the site-wide concentrations. There are at least three factors that have probably altered upgradient conditions in the 100-K Area. First, the ground water mound that apparently existed underneath the site during reactor operations probably resulted in contaminant migration away from the site in all directions. Because the ground water mound apparently dissipated when reactor operations ceased and the natural gradient north toward the Columbia River was reestablished, contamination that migrated to the south of the site when the mound was present would be upgradient when the natural northern gradient was reestablished. Second, local reversal of the ground water flow as a result of river level fluctuations may alter upgradient conditions, particularly along the 116-K-2 trench, which is relatively close to the river. Third, ground water migration from facilities outside of the 100-K Area may impact upgradient conditions. For example, contamination has apparently migrated from the 200 Areas in the unconfined aquifer through Gable Gap (Plate 1).

3.1.3.2 Ground Water Contamination.

3.1.3.2.1 Shallow Ground Water (Producing Layers A and B). Shallow ground water, in and around the 100-K Area, has been contaminated as a result of site waste disposal practices. A site map indicating the minimum and maximum concentrations of selected chemical constituents in 1988 is presented in Figure 3-5. Concentrations of select ground water contaminants are summarized in Tables 3-19 through 3-22 and Figures 3-6 through 3-14. Some of the wells monitor Hanford formation as well as the uppermost Ringold; other wells monitoring producing and confining units A and B.

Parameter selection was based on known contaminant problems elsewhere within the Hanford Site and on available data. Specific wells were selected because they are considered representative of the variety of conditions that may be encountered, including upgradient conditions, and the length of their data record. The selected wells include two upgradient wells (6-66-64 and 6-72-73); one well approximately in the center of the 100-K Area (K11); the four wells around the 105-KE fuel storage basin (K27 through K30); and three wells along the 116-K-2 trench (wells K19, K20, and K22).

Because of the limited amount of data, meaningful contaminant plume maps for the 100-K Area cannot be prepared at this time. Because of the numbers of potential sources and their different time frames, there may be overlapping plumes that would not be distinguishable with the present data. However, the available data do provide at least qualitative information on potential source locations and intensity.

Temperature--Temperature data are considered to represent process impacts because of the high temperatures of the discharging cooling water and continued heat transfer resulting from radioactive decay in contaminated soil and similar sources. Ground water and spring temperatures also reflect the influence of back storage. Table 3-19 is a summary of available ground water temperature data for select wells, and Figures 3-6 through 3-8 are graphs of these data. The period of record is relatively short (beginning in 1976) about 5 yr after reactor operations ceased; therefore, it is not known if the ground water temperatures declined as did the water levels when operations ceased.

In general, the ground water temperatures range from about 15 to 19°C. However, there are variations that may be indicative of potential offsite and onsite sources ground water temperatures in wells near the Columbia River also may be affected by inflow of river water when river stage is high. The temperature in the upgradient well 6-66-64 has apparently increased. In 1976, it was about 14.5 to 15.5°C, and in 1986 it was about 17 to 17.5°C. This increase corresponds to an increase in tritium concentrations in this well, as discussed in the next section. This may represent contamination from the 200 Areas migrating laterally in the unconfined aquifer through Gable Gap (Plate 1). In contrast, the temperatures in well K30 (near the 105-KE fuel storage basin) are not high in relation to the other wells measured even though it has much higher tritium concentrations. The temperatures in the three wells along the 116-K-2 trench (K19, K20, and K22) range from 19 to almost 25°C, which is significantly higher than those for any of the other wells considered. Also, the temperature in well K19 has been increasing since 1976. This range of temperature is higher than even the maximum reported temperature for the Columbia River upstream of the Hanford Site (Section 3.1.4). This difference indicates there is probably a radionuclide source in the soils associated with the 116-K-2 trench.

The temperatures for the springs along the riverbank is summarized along with their descriptions on Table 2-5. The values cover a wide range, from 8.8 to 17.3°C, although most are on the order of 11 to 13°C. Some of the higher temperatures 13 to 15.4°C are opposite the 116-K-2 trench (spring designations 7-1 and 7-2), which would correlate with higher ground water temperatures in wells K19, K20, and K22 (McCormack and Carlile 1984).

Tritium--Tritium, which is present in many Hanford Site waste streams, is a very mobile radionuclide in ground water and therefore serves as a good indicator for the extent of contamination from site operations. Well K30 currently is the only well in which the concentration of tritium is greater than the drinking water standard of 20,000 pCi/L (Evans et al. 1989). Table 3-20 is a summary of available tritium data for select wells, and Figures 3-9 through 3-11 are graphs of those data. Similar to the temperature data, the period of record is relatively short and begins after reactor operation ceased.

The available tritium concentrations from the wells evaluated exceeded the background concentration of 200 pCi/L. Tritium concentrations generally range from 1,000 to 5,000 pCi/L, based on data from one of the background wells (6-72-73), two of the wells along the 166-K-2 trench (K21 and K22), and two of the wells near the 105-KE fuel storage basin. The higher overall 100-K Area tritium concentrations, as compared to the natural tritium concentrations, are probably residual from the ground water mound created by process water infiltration. However, like the other temperature data, there are variations that may be indicative of existing offsite and onsite sources. In well 6-66-64, the tritium concentration increased from 1,500 to 6,000 pCi/L between 1976 and 1986, which may represent contamination from the 200 Areas migrating laterally in the unconfined aquifer through Gable Gap (Plate 1). Conversely, the tritium concentrations in two onsite wells (K11 and K28) show significant declines from over 10,000 pCi/L in the early 1980s to less than 4,000 pCi/L in 1989, indicating cessation of a presently unidentified source. A recent source, the 105-KE fuel storage basin, has apparently contributed to the elevated tritium concentrations in wells K29 and K30. Tritium concentrations in well K19 indicates the well is also being influenced by an unidentified source. In well K19, the tritium concentration rose starting in 1980 to a high of about 50,000 pCi/L and subsequently declined to about 5,000 pCi/L.

Tritium concentrations in three spring samples collected in 1982 along the Columbia River shoreline adjacent to the 100-K Area range from about 870 to 5,490 pCi/L. The lowest concentration is upstream of the 100-K Area (spring 5-4A on Figure 2-16), and the highest concentration is on the northwest corner of the 100-K Area (spring 6-1). The intermediate concentration, 1,400 pCi/L, was from spring 7-1 on the northeast corner of the main portion of the site.

Nitrate--Nitric acid, used in reactor decontamination, is a major source of nitrate in the ground water beneath the 100 Areas. Nitrate concentration greater than the MCL of 45 ppm have been noted in wells K11, K19, and K30. Table 3-21 is a summary of available nitrate data for select wells, and graphs of nitrate concentrations versus time are included in Figures 3-12 through 3-14. The trends in the nitrate concentrations are similar to the trends in the tritium concentrations. This is not unexpected considering both contaminants are found in reactor cooling water discharges.

Several of the wells show limited or no evidence of contamination (nitrate concentrations generally less than 10 ppm), but others indicate potential onsite and offsite sources. In the upgradient well 6-66-64, the nitrate concentration has increased from 10 to 20 ppm, along with the temperature and tritium concentrations. The nitrate concentration in well K11 is relatively high and may be due to effects from adjacent, active septic tanks and drainfields. The elevated nitrate concentrations in wells K29 and K30 (20 to 60 ppm) correspond to elevated tritium concentrations. Wells K19 and K20 have apparently been affected by an onsite source (20 to 95 ppm).

Hexavalent Chromium--Hexavalent chromium (Cr^{+6}) is also a contaminant of concern in and around the 100 Area. During reactor operations, sodium dichromate was used to control oxidation of aluminum parts of the cooling systems, while chromic acid was also used to decontaminate dummy fuel elements.

The Cr^{+6} reported values of above drinking water standards appear to be consistent and reproducible over the reporting periods. It is not clear from the literature (Evans et al. 1989) if the relatively recent occurrence of chromium (first appearing in the database in early 1987) is because Cr^{+6} analyses were not requested before 1987, or because the Cr^{+6} was not detected in samples collected before 1987.

The only other trend apparent in the Cr^{+6} data is the variation in concentrations along the 116-K-2 trench. In well K19 at the northwest corner of the main portion of the trench, the Cr^{+6} concentration is approximately 100 ppb. In well K20 the concentration is approximately 140 to 170 ppb. In the well most distant from the inlet end of the trench (K22), the concentration is about 185 to 230 ppb. This increase is the opposite of the decrease noted in tritium and nitrate concentrations. The reason for the differing trends is not yet known but could result from differences in contaminant mobility, the preferential distribution of Cr^{+6} in the trench, or influence of adjacent operable units (e.g., 100-N Area).

The Cr^{+6} concentrations have exceeded the drinking water standard of 50 ppb at three monitoring well locations (wells K19, K20, and K22) in the 100-K Area and in one of two nearby 600 Area wells (well 6-73-61) where measurable quantities were noted (wells 6-73-61 and 6-78-62). Trace amounts of CR^{+6} at or below the detection limit of 10 ppb were also noted in three of the four wells (K27, K28 and K30) adjacent to the 105-KE fuel storage basin, in the centrally located K11 well, and in 600 Area wells 6-70-68 and 6-72-73. Table 3-22 provides a summary of available Cr^{+6} analytical results. The Cr^{+6} concentrations were not plotted as a function of time because of the limited amount of data. No Cr^{+6} data currently are available for the springs along the Columbia River shoreline.

3.1.3.2.2 Deeper Ground Water (Ringold Layers 2C and B, and the Rattlesnake Ridge Interbed). The presence or absence of contamination in deeper producing layers has not yet been determined at the 100-K Area. Well 199-B32-2 in the 100-B/C Area, which is completed at the base of the Ringold and in the basalt, is reportedly contaminated, but this may be the result of well construction difficulties rather than downward contaminant migration into the aquifer.

3.1.4 Surface Water and River Sediment

Routine monitoring of Columbia River water and sediment began in 1945, soon after the startup of operations at the Hanford Site, and continues today as part of the Hanford Environmental Surveillance Program (see Jaquish and Bryce 1989). The monitoring programs have undergone several changes over the years in response to changing operational conditions and improved monitoring techniques. Throughout the years, sample locations have been maintained upstream of the Hanford Site, away from the influence of site operations to provide information on the background conditions in the Columbia River. Other sample locations downstream of all site facilities identify impacts from Hanford Site operations. The purpose of the monitoring programs has been to determine the overall impact of these operations. Increases in contaminant concentrations observed downstream of Hanford usually cannot be attributed to any one facility or operation.

Several surveys relating to specific aspects of contamination in the Columbia River and its associated sedimentary deposits have been completed as part of PNL's Hanford Environmental Surveillance Program. A comprehensive radiological survey, including collection of sediment samples, was completed during 1979 by Sula (1980). This survey focused on selected areas identified during previous surveys (especially aerial surveys performed in 1974 and 1978; Tipton 1975) and also on areas most likely to be used by the public.

The survey included both banks of the Columbia River, from the 100-B Area downstream to the confluence of the Columbia and Snake rivers. Elevated radiation levels were measured at 92 of approximately 30,000 measurement locations, and the elevated levels were attributed to concentration of contaminated sediment by natural depositional processes of the Columbia River. The highest levels were found at the White Bluffs Slough (near the 100-H Area), at the Hanford Townsite Peninsula, and adjacent to the 300 Area. Sampling results suggested that the source of radiation in sediment was discreet metallic flakes containing ^{60}Co radiation.

During 1982 and 1983, an investigation of the seepage of ground water from the Hanford Site into the Columbia River along its banks was conducted to supplement the site-wide surveillance program (McCormack and Carlile 1984). The study included sampling 115 'springs' during the low river level, between Vernita Bridge and Richland. It also included sampling river water adjacent to the springs. Analyses for tritium, nitrate, and uranium were used as indicators of contamination. While elevated levels of these indicators were observed, none exceeded applicable DOE concentration guides. In addition to providing chemical data on ground water seepage into the Columbia River, the study established a sampling protocol for future surveys of riverbank seepage.

An independent investigation of 36 ground water seeps along the Hanford Site shoreline and sediments from 46 locations along the riverbank was completed in 1988 by SEARCH Technical Services (Buske and Josephson 1988). The sampling program complemented earlier sampling results obtained by McCormack and Carlile (1984), and followed the same protocol for collecting samples of ground water seepage. Sediment and water samples were analyzed for radionuclides having a half-life of greater than 1 yr. Results of the investigation support the hypothesis that radionuclides are incompletely attenuated by Hanford Site soils during their transport by ground water flow towards the Columbia River. Low levels of long-lived radionuclides were detected in sediment samples in the vicinity of reactor areas and near the 300 Area.

Results of the Hanford Environmental Surveillance Program are published annually. The following sections provide an overview of the known and potential contaminant concentrations present in the river system and are summarized from the most recent annual report of the program (Jaquish and Bryce 1989).

3.1.4.1 Background Surface Water Quality. Columbia River water samples are collected upstream of Hanford facilities at Priest Rapids Dam and near the Vernita Bridge to provide background data from locations unaffected by site operations (Jaquish and Bryce 1989). Samples collected at Priest Rapids Dam are analyzed for radiological constituents, while nonradiological analyses are performed on samples collected near the Vernita Bridge as part of the surface environmental monitoring project. Water quality of the Columbia River is also monitored by the U.S. Geological Survey (USGS) as part of the National Stream Quality Accounting Network, which provides primary hydrologic and nonradiological water quality data (McGavock et al. 1987).

Two methods of water sampling were used to collect radiological samples: a composite system that collected fixed volumes of water at set intervals at each location during each sampling period and a specifically designed system that continuously collected waterborne radionuclides from the river on a series of filters and ion-exchange resins. As seen in Table 3-23, radionuclide concentrations in the river water upstream of 100-K Area were extremely low in 1988 (Jaquish and Bryce 1989).

Several of the radionuclides identified are undetectable without the use of special sampling techniques or analytical procedures. Radionuclides consistently found i measurable quantities in river water are ^{3}H, ^{90}Sr, ^{129}I, ^{234}U, ^{235}U, ^{238}U, and $^{239/240}Pu$. These radionuclides exist in worldwide atmospheric fallout, as well as in effluents from Hanford Site facilities. In addition, tritium and uranium occur naturally in the environment. The 1988 average radionuclide concentrations shown in Table 3-23 are more than an order of magnitude lower than the applicable drinking water standards in all cases (Jaquish and Bryce 1989).

Nonradiological water quality data for the Columbia River upstream of the Hanford Site are summarized in Table 3-24. The data are used as indicators of water quality, and include a number of parameters for which no regulatory limit has been set.

3.1.4.2 Surface-Water Contamination. Radiological and nonradiological pollutants are known to enter the Columbia River along the Hanford Reach (Stenner et al. 1988). In addition to direct discharges from Hanford Site facilities, effluent contaminants discharged to ground water years earlier are known to enter the river from springs. Nonradiological pollutants entering the river may originate from irrigation returns and ground water springs contaminated by the extensive agricultural practices north and east of the river.

The nearest Columbia River water samples collected downstream of the 100-KR-4 operable unit were taken at the 300 Area water intake and the city of Richland pumphouse. These samples are used to identify any possible influence on contaminant concentrations from Hanford Site operations (Jaquish and Bryce 1989). Samples from the 300 Area water intake are analyzed for radiological constituents (Table 3-25), while the Richland pumphouse samples are analyzed for radiological and nonradiological parameters (Tables 3-26 and 3-27). All radionuclide concentrations observed during 1988 at the 300 Area water intake and the Richland pumphouse were well below applicable drinking water standards.

Except for three analytes, concentrations observed at the 300 Area water intake and the Richland pumphouse were similar to those observed at Priest Rapids Dam, indicating no measurable effect from Hanford Site operations at these locations. Only ^{3}H, ^{90}Sr, and ^{129}I concentrations appeared to be significantly higher at the city of Richland pumphouse than at Priest Rapids Dam, thus indicating a possible influence from Hanford Site operations. The statistical analysis consisted of a paired sample comparison, using Student's t-test of differences and a 5% significance level. No other significant differences were noted between concentrations of radionuclides at the 300 Area water intake, city of Richland pumphouse, and Priest Rapids Dam during 1988 (Jaquish and Bryce 1989).

Nonradiological river water quality data at the Richland Pumphouse for 1988 are summarized in Table 3-27. In general, concentrations of nonradiological water quality parameters were similar at Priest Rapids Dam and the city of Richland pumphouse. There is no indication of any significant nonradiological deterioration of water quality along the Hanford Reach of the Columbia River resulting from Hanford Site operations. As was the case at Priest Rapids Dam, applicable standards for Class A waters were met at the Richland pumphouse (Jaquish and Bryce 1988).

Although available data show the levels of radiological and nonradiological contaminants in the Columbia River water to be low, localized areas of elevated concentrations attributable to the 100-KR-4 operable unit may exist.

3.1.4.3 Background Sediment Quality. Columbia River sediment has been sampled intermittently since 1945. Routine sediment sampling occurred from 1945 to 1960. Background sediment sampling for the Hanford Site was conducted at Priest Rapids Dam in 1976 (Robertson and Fix 1977) and special studies were ongoing in the late 1970s and early 1980s (Sula 1980; Beasley et al. 1981). Cesium-137 was the most abundant fallout radionuclide detected, with trace amounts of ^{238}Pu, $^{239/240}$Pu, and ^{241}Am also present in the 1977 study.

Sediment sampling above Priest Rapids Dam (upstream of the Hanford Site) and McNary Dam (downstream of the Hanford Site) recently resumed as part of the surface environmental monitoring project. Results of analyses on samples collected during 1988 were published by Jaquish and Bryce in 1989 (Table 3-28). Radionuclide concentrations observed above Priest Rapids Dam reflect concentrations upstream of all Hanford facilities and thus provide background information on sediment concentrations for the 100-KR-4 operable unit. Analyses of the sediment samples included gamma scans, ^{90}Sr, ^{235}U, ^{238}Pu, and $^{239/240}$Pu. Background information for chemical constituents in sediment is not available.

3.1.4.4 Sediment Contamination. Radionuclides, including neutron activation products, fission products, and trace amounts of transuranics, were discharged into the Columbia River from early plutonium production in the 100 Areas. The radioactive material was dispersed in the river water and some was absorbed onto detritus and inorganic particles, incorporated into the aquatic biota or, in the case of larger particles of insoluble material, deposited on the riverbed. Some of this material has been deposited along the shoreline areas above the low river level. Radiation surveys of the exposed shorelines, from the Vernita Bridge upstream from the 100-B/C Area, to the confluence of the Snake River, during 1978 and 1979 revealed areas within and adjacent to 100-K Area with elevated exposure rates (>25 μR/hr). The maximum reading for this area was measured at 250 μR/hr in an area that extended approximately 450 ft (150 m) downstream of 107-K retention basins on the Hanford Site (south) side of the Columbia River (Sula 1980).

Results from recent sediment-sampling activities at McNary Dam are available for calendar year 1988 (Jaquish and Bryce 1989) and are summarized in Table 3-28. Surface sediments behind McNary Dam are known to contain low levels of Hanford origin radionuclides (Robertson and Fix 1977; Beasley et al. 1981) in addition to radionuclides from general atmospheric fallout. Concentrations of ^{60}Co, ^{90}Sr, ^{134}Cs, ^{137}Cs, ^{238}Pu, and $^{239/240}$Pu were higher in sediments from behind McNary Dam than from behind Priest Rapids Dam (Jaquish and Bryce 1989). At this time, it is not known if, or what percentage, the 100-K Area operations contributed to these higher-than-background radionuclides in sediments behind downriver dams. Data on chemical characterization of sediments are not currently available.

3.1.5 Air

Routine monitoring of the air, both on and off the Hanford Site, has occurred since the early production operations. The focus of these programs has been airborne radionuclides. For a more detailed discussion of meteorology and air monitoring, see Sections 2.2.5 and 3.1.5 of the 100-KR-1 operable unit work plan.

3.1.6 Biota

3.1.6.1 Aquatic Biota. Site-specific data concerning the contamination levels of aquatic fauna in 100-KR-4 operable unit vicinity are sparse. However, applicable data from other resources are available to identify the extent of aquatic biota contamination. For example, Jaquish and Bryce (1989) have published data on contamination in whitefish muscle and carcass collected upstream of the Hanford Site boundary and downstream near the 100-D Area (Table 3-29). Similar data are available for years before 1988 in the annual Hanford Site radiological surveillance reports. The levels reported in earlier years, prior to 1980, are similar to those shown in Table 3-29. An extensive survey with applicable data, was collected in the 100-F Area downstream from the 100-KR-4 operable unit 1966-1967 while the reactors were operating. The data represents radionuclide concentrations collected under those conditions (Watson 1970).

Cushing (1979) presents data on concentrations of 22 stable trace elements in phytoplankton, caddisfly, larvae, and whitefish muscle. All these samples were collected from the Columbia River, downstream of the 100-B/C Area including the 100-K Area.

3.1.6.2 Riparian Biota. The Columbia River shoreline adjacent to the 100 Area is a narrow band of riparian vegetation dominated by reed canary grass and other grasses, sedges, and rushes.

Strontium-90 was measured in the leaves and stems of reed canary grass in the riparian zone at selected locations downstream from the 100-KR-4 operable unit as far as the city of Richland. The highest concentrations were measured in samples collected near the 100-N Area, and the lowest near Richland. Concentrations were greater in samples collected near the 100 Areas than they were at the White Bluffs Ferry Landing downstream from the 100-H Area. Tritium was measured in leaf water extracted from six black locust trees growing just upstream of the 100-KW water intake. Maximum tritium concentrations were 12,000 pCi/L. This was greater than the concentrations of tritium in well water sampled near the trees. Strontium-90 was measured in the egg shells of Canadian geese nesting on islands in the Columbia River downstream from the 100-KR-4 operable unit near the 100-H Area. Nests from an island near Ringold had slightly enhanced levels of ^{90}Sr. However, the concentrations are too low to observe health or reproductive defects in wild geese (Rickard and Price 1989).

It is expected that deep-rooted plants growing in the riparian zone of the Columbia River can serve as biological indicators of chemical contamination in the riparian environment (Rickard et al. 1978; Fitzner et al. 1981). Cadmium and mercury have been measured in the nest debris (feces and food scraps) at one Hanford Site heron rookery. The levels of these metals found in herons on the Hanford Site, however, are lower than those reported elsewhere in the northwest (Fitzner et al. 1981). Heavy metal concentrations have also been examined in eggs and in young herons from the

Hanford Site. No elevated levels were detected for lead, copper, zinc, or mercury (Blus et al. 1985). These data, however, provide a useful baseline for comparison with future years.

Birds of prey, particularly owls, have been implicated in the spread of radionuclides near the 100-D, 100-F, and 100-H Areas (Caldwell and Fitzner 1984). Pellets (regurgitated, undigestible prey remains) were found that contained ^{54}Mn, ^{60}Co, ^{137}Cs, and $^{152,154,155}Eu$, and two naturally occurring radionuclides, ^{40}K and ^{226}Ra. The mean ^{137}Cs concentration for barn own pellets collected near these areas was 3.1 $\pm$1.1 pCi/g dry weight. Pellet analysis indicated these owls were feeding mostly on small mammals.

3.1.7 Site Conceptual Model

The data and evaluations discussed previously are integrated and summarized in the form of a preliminary site conceptual model.

The two-fold purpose of the site conceptual model is to focus the RI/FS process and provide a basis for the initial risk assessment. Many data are available but, as stated previously, they have limited use. These data were generally collected for other purposes and, therefore, may not be suitable for the RI/FS process. The site conceptual model is shown schematically in Figure 3-15. The contaminant sources, mechanisms for these contaminants to be released into other environmental media, and potential pathways and receptors are summarized in this schematic. This schematic, together with estimates of key parameters such as contaminant concentrations, is part of the basis for modeling the initial human risks associated with the various contaminants, pathways, and receptors.

The conceptual model is used to qualitatively express the best estimates of understanding of the spatial distribution of contaminants in various media, contaminant pathways, contaminant sources, physical and chemical characteristics of various media. Key aspects of the site conceptual model are summarized in the following sections.

3.1.7.1 Sources. Although the potential contamination sources are numerous, the major known sources of contamination that may affect ground water quality are listed below:

- Cooling water retention basins
- Associated liquid waste disposal crib and trench
- Leak in the 105-KE fuel storage basin.

Other potential sources of contamination that are considered less significant, based on the current knowledge of the site, are listed below:

- Sludge that remains in the retention basins
- Radiological contamination that remains in the ground at the effluent crib and trench

- 115-KE and KW percolation cribs
- 1706 KER percolation crib
- 100-K Area burial grounds
- 105-KE and KW reactors
- KE and KW thimble caves
- Percolation trench used for sulfuric acid sludge disposal
- Percolation reverse wells used for sulfuric acid sludge disposal
- Percolation french drains used for sulfuric acid sludge disposal.

The highest-known concentrations of beta-gamma radiation in the 100-K Area occur in the retention basin sludge, the retention basin fill dirt, the soil adjacent to the basins, the scale and sludge that remain in the cooling water effluent pipelines, and the soil in the 115-KE and -KW, and 1706-KER percolation cribs (Dorian and Richards, 1978). Radiological contamination has been shown to extend to a depth of at least 20 ft (7 m) beneath most of the waste disposal sources sampled. The 100-KR-1 operable unit is the largest source operable unit in the 100-K Area on the basis of surface area. Practices in the 100-K Area are believed to have led to much of the existing ground water contamination in the area although other sources may contribute as well. Source information will be required to effectively screen remedial alternatives in the feasibility stage of the RI/FS.

Information on nonradiological contamination at the site is sketchy and is limited primarily to information on the chemicals used at the site and ground water sampling data. Large volumes of sodium dichromate were added to the cooling water to inhibit corrosion of the cooling water system in the reactor. Also, chromic acid was used as a decontamination solution in the reactor. Thus, it is assumed that the main sources of chromium at the site are associated with the cooling water effluent facilities, particularly the sludge in the basins and pipelines. The source of nitrate, which has been detected in ground water in the 100-K Area and vicinity, is assumed to be from the nitric acid used for decontamination procedures.

Limited data are available on the use of organic chemicals onsite. PCB-containing transformers and hydraulic machinery were used in the 100-K Area. The use of organic solvents has been mentioned in hearsay evidence, and solvent storage tanks have been noted in review of building plans. There are no sampling or analysis data concerning organic wastes, or contamination in the source areas of the vadose zone soils.

Another potential source is contaminated ground water in low permeability material and in dead-end pore space within the aquifer and contaminated ground water from other locations on the Hanford Site. Diffusion of contaminants out of the pore space is believed to be slow, but perhaps long term. Understanding the magnitude and rate of release from dead-end pores may affect remedial alternative screening and selection. Understanding the nature and extent of contaminants in ground water flowing into the 100-K Area may also affect remedial alternative screening selection.

3.1.7.2 Vadose Zone. The vadose zone consists primarily of relatively coarse-grained, unconsolidated sediments (such as gravels) from ground surface to the water table. Key elements of the conceptualization of the vadose zone are listed below.

- The lithology of the vadose zone is variably but consists primarily of permeable sands, gravels, cobbles, and boulders of the Hanford Formation (informal designation). Veneers of fill, loess, and alluvium locally overlie the Hanford formation. Less permeable cemented gravels of the Ringold Formation are present beneath much of the site.

- The thickness of the vadose zone (i.e., the depth to ground water) underneath the 100-K Area ranges from about 0 to 80 ft (0 to 24 m), with the thinner portions closer to the Columbia River (i.e., beneath the 100-KR-1 operable unit). When the 100-K reactors were in operation, the vadose zone locally was thinner as a result of the ground water mound formed by cooling water infiltration. Also, fluctuations in the river level and subsequent fluctuations in the shallow ground water level affect the thickness of the vadose zone.

- Lower permeability lenses of finer-grained sediments in the vadose zone, such as silts and the cemented gravels, may have restricted downward movement of infiltrating liquid wastes, resulting in a greater potential for lateral migration. Locally, higher permeability lenses or layers could create channels for contaminant migration.

- The sediments and interstitial water in the vadose zone have been contaminated with various radionuclides and possibly other materials from the disposal of liquid and solid wastes within the 100-KR-1, -2, and -3 source operable units. Most of the contaminants found in the vadose zone are probably residual from the infiltration of large volumes of cooling water during reactor operations. In contrast, the rates of subsequent natural infiltration are low, therefore current contaminant migration rates through the vadose zone are probably low.

- Contaminants present in the capillary portions of the vadose zone, (i.e., the contact with the water table) may be (or have been) more mobile than in the shallower portions of the vadose zone. More rapid dissolution or leaching of contaminants would be expected as a result of frequent water level fluctuation in the capillary portion than from sporadic surface water infiltration throughout the vadose zone.

3.1.7.3 Ground Water System. The hydrogeologic system in the 100-KR-4 operable unit is conceptualized as being layers of coarse- and fine-grained sediments overlying basalt. The significance of the stratification is that ground water movement and contaminant transport are largely controlled by the nature and extent of the various strata in conjunction with the magnitude of the lateral and vertical hydraulic gradients. The initial conceptualization of the hydrogeologic system in profile is illustrated in Figure 3-16. The following list describes the key hydrogeologic and water quality elements of the site conceptual model.

- The unconfined aquifer occurs in the relatively permeable sediments of the Ringold Formation. Locally, lower permeability layers affect ground water and contaminant flow by physical means (e.g., smaller pore size) or chemical means (e.g., reaction with cementing material). The unconfined aquifer consists of sands and gravels with some zones of cementation.

- The depth to ground water underneath the 100-K Area ranges from about 0 to 75 ft (0 to 25 m) below the surface. The shallower depths are closer to the river as a result of topographic variations across the site. When the 100-K reactors were in operation, the depth to ground water may have locally been as much as 25 ft (8 m) shallower because of the ground water mound formed by cooling water infiltration.

- In general, the ground water flow in the upper portion of the unconfined aquifer is to the north-northwest, (toward the Columbia River). Changes in the river stage may directly affect the direction and rate of ground water flow beneath the 100-K Area. Historically, the ground water flow direction may have been radial from the 100-K Area due to the ground water mound created by cooling water infiltration.

- The upper portion of the unconfined aquifer has been contaminated with tritium, nitrates, and chromium as a result of the operations in the 100-K Area. Contaminants in sediments within both the current and historic zones of water table fluctuations may be released more rapidly to the ground water than shallower contamination. The difference in leaching rates results from the rapid variations in water level because of the river influence versus slow recharge rates from infiltration of precipitation.

- Upgradient wells may have been influenced by the historic ground water mound and/or contaminant movement from offsite areas, such as from the 200 East and West Separations Areas through Gable Gap.

- A confined aquifer occurs in Ringold unit 3, which is overlain by a thick clay unit (Ringold unit 2c), and another occurs in the Rattlesnake Ridge Interbed, which is overlain by a thick basalt unit. The depths to the tops of these two confined aquifers beneath the 100-K Area are estimated to be about 500 and 650 ft (164 to 213 m), respectively. A confined aquifer is also thought to exist within Ringold unit 2, overlain by Ringold unit 2a and underlain by Ringold unit 2c.

- It is not expected that any contaminants in the shallow portion of the unconfined aquifer have migrated downward into the confined aquifers. Both the expected vertical upward gradient from the confined aquifers, and the thickness and characteristics of the confining layers reduce the likelihood of downward contaminant migration. However, locally, ground water mounding may have induced a downward vertical gradient.

3.1.7.4 Surface Water and Sediments. Ground water from the upper portion of the unconfined aquifer discharges to the Columbia River through springs near the river level and as baseflow through the riverbed. Based on samples from some of the 100-K Area wells, this ground water contains tritium, nitrate, and chromium at concentrations above drinking water standards. However, drinking water standards of these constituents are not believed to be exceeded in the Columbia River because of dilution. Recreational users at a point of ground water discharge (e.g., springs) would potentially be endangered if the water were ingested before being received and diluted by the river, or by direct contact with exposed sediments contaminated by the springs.

Contaminants are expected in association with near-shore sediments where ground water from the 100-K Area is discharging to the Columbia River. Any threats to the environment or public health from contaminated sediments is probably through the food chain where aquatic plants would uptake contaminants from the sediments and associated ground water.

3.1.7.5 Aquatic Biota. Although there are few site-specific data on aquatic biota in the 100-K Area, studies at other 100 Area sites and ongoing Hanford Site environmental monitoring provide sufficient information for a general understanding of the biota at the 100-K operable unit. Potential pathways that could affect biota or create human risk begin with plant uptake of contaminants from sediments or aquatic organism intake of contaminated ground water as described in Section 3.1.7.4. Other potential pathways include resident and visiting wildlife ingestion of vegetation and aquatic organisms from the riparian zone and aquatic environments in and along the Columbia River.

3.1.7.6 Terrestrial Biota and Air. The conceptual models for the transport of contaminants via the terrestrial biota and air pathways is discussed in detail in the 100-KR-1 operable unit work plan. Because of the depth to ground water [0 to 80 ft (0 to 24 m) below surface] and the veneer of clean fill over most of the site, the potential for contaminant transport by these pathways does not appear to be significant. However, during the field RI, drilling may result in contaminants being brought to the surface. This, in conjunction with factors such as wildlife movement and frequent winds at the site, will require strict adherence to health and safety procedures, dust control measures, and soil and ground water containment procedures during activities such as drilling.

3.2 POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Remedial action at the 100-KR-4 operable unit is generally required to comply with federal and state environmental laws and promulgated standards, requirements, criteria, and limitations that are legally applicable or relevant and appropriate where there is release or threatened release of hazardous substances, pollutants, or contaminants. This is referred to as compliance with ARARs.

Three categories of potential ARARs will be evaluated. There are chemical-specific ARARs, location-specific ARARs and action-specific ARAR's. When the requirements in each of these categories are identified, a determination must be made as to whether those requirements are applicable or relevant and appropriate. A requirement is applicable if specific term jurisdictional prerequisites of the law or regulations directly address the circumstances at a site. If not applicable, a requirement may nevertheless be relevant and appropriate if circumstances at the site are, based on best professional judgement, sufficiently similar to the problems or situations regulated by the requirements.

To-be-considered (TBC) materials are nonpromulgated advisories or guidance issued by federal or state governments that are not legally binding and do not have the status of potential ARARs. However, in some circumstances TBCs will be considered along with ARARs in determining the necessary level of remediation for protection of human health and the environment.

The EPA has developed a two-volume guidance document for preparing ARARs in *CERCLA Compliance with Other Laws* (EPA 1988d). Categories of potential ARARs are as follows:

- Ambient or chemical-specific requirements are usually health or risk-based numerical values or methodologies that, when applied to site-specific conditions, result in establishment of numerical values. These values establish the acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment.

- Performance, design, or other action-specific requirements are usually technology- or activity-based requirements or limitations of remedial actions.

- Location-specific requirements are restrictions placed on the concentration of hazardous substances or the conduct of activities solely because they occur in special locations.

Potential chemical- and location-specific ARARs are identified based on the compilation and evaluation of existing site data. These ARARs need to be refined during the FS process by EPA, Ecology, and DOE. Potential action-specific ARARs are discussed in this section and will be identified during development of alternatives in the RI/FS tasks.

3.2.1 Chemical Specific Requirements

A chemical-specific requirement sets concentration limits in various environmental media for specific hazardous substances, pollutants, or contaminants. Contaminant exposure pathways include ingestion of soils and biota, inhalation of particulates, dermal contact with soils and building rubble, and exposure to radiation. There are federal and state standards for air and water quality; however, there are no soil remediation standards except for PCBs and uranium mill tailings. Typically, radiation standards and health-related values are used to back-calculate acceptable remediation levels for soil contaminants. The identified potential federal and state ARARs are summarized in the following sections.

3.2.1.1 Federal Requirements. Federal chemical-specific requirements come from the Code of Federal Regulation (CFR).

3.2.1.1.1 U.S. Nuclear Regulatory Commission (NRC) Standards for Protection Against Radiation (10 CFR 20). These regulations apply to activities licensed by the NRC and specify radiation dose standards for individuals in restricted water in unrestricted areas. The standards for emissions to water in unrestricted areas are potential ARARs, both for ambient conditions and during any remedial action that can affect a water pathway. These standards are listed in Table II, Appendix B, for various isotopes. For example, the standards for concentrations in water above background (soluble values) range from 3 x 10^{-3}) μCi/mL for ^{3}H to 3 x 10^{-4}) μCi/mL for ^{99}Tc to 4 x 10^{-5} μCi/mL for ^{238}U.

3.2.1.1.2 EPA Safe Drinking Water Act (40 CFR 141). The Safe Drinking Water Act provides for the establishment of drinking water quality standards for public water systems. These standards presented in Table 3-30 are of interest for the Hanford Site.

Table 3-31 provides the annual average concentration limits for various manufactured radionuclides. These radionuclides are assumed to yield an annual dose of 4 mrem to the indicated organ.

3.2.1.1.3 EPA Clean Water Act Water Quality Criteria (40 CFR 121). Section 121 of CERCLA states that remedial actions shall attain federal water quality criteria where they are relevant and appropriate under circumstances of the release or threatened release of hazardous constituents. The water quality criteria for the protection of cold water aquatic life are potential ARARs for the Columbia River because of the fisheries present in the river.

3.2.1.2 Washington State Requirements. State chemical-specific requirements are discussed in more detail in the following subsections.

3.2.1.2.1 Washington Standards for Protection Against Radiation (WAC 402-24). These regulations specify radiation dose standards for permissible levels of radiation in unrestricted areas. Table II of Appendix A of 10 CFR 20 itemizes the allowable concentrations in air above natural background.

3.2.1.2.2 Washington State Drinking Water Standards (Rules and Regulations of the State Board of Health, Chapter 248054). These regulations are identical to those promulgated under the Safe Drinking Water Act for the contaminant of concern.

3.2.1.2.3 Washington Water Quality Standards (WAC 173-201). These standards list the water quality of the Hanford Reach of the Columbia River as Class A or excellent (Table 3-32).

3.2.1.2.4 Washington Dangerous Waste Regulations; Ground Water Protection (WAC 173-303-G45). These regulations list MCLs for several site contaminants; the standards are identical to the ones promulgated under the Safe Drinking Water Act.

3.2.2 Action-Specific Requirements

Action-specific ARARs are requirements that are triggered by specific remedial actions at the site. These remedial actions are not fully defined until the FS phase. However, the universe of action-specific ARARs defined by a preliminary screening of potential remedial action alternatives will help focus the FS alternatives.

3.2.3 Location-Specific Requirements

Location-specific ARARs identify requirements for site activities that are triggered by site location. These can include sensitive habitats, floodplains, fault locations, historical and prehistorical resources, and wetlands (Table 3-33).

3.2.4 Other Advisories, Criteria, or Guidance To Be Considered

In addition to listed ARARs, there are other federal and state criteria advisories, or guidance to be considered in determining the appropriate degree of remediation for the 100-KR-4 operable unit. These additional items are summarized in the sections that follow.

3.2.4.1 Health Effects Assessment. Some compounds detected at the 100-KR-4 operable unit may not have MCLs, state water quality criteria, or radiation criteria. For individual carcinogens that do not have federal or state standards, but have a carcinogenic potency factor, ground water and soil concentrations can be calculated that would result in a 10^{-4} to 10^{-6} excess lifetime cancer risk by inhalation or ingestion. Excess lifetime cancer risk is defined as the incremental increase in the probability of developing cancer compared to the background possibility. For noncarcinogenic compounds, reference doses (RD) or acceptable chronic intakes can be used to estimate concentrations that would result in no observable adverse health effects by ingestion or inhalation.

3.2.4.2 Federal Health Advisories. Federal health advisories issued by the EPA Office of Drinking Water, cite the current assessment of contaminant concentrations in drinking water at which adverse health effects would not be anticipated to occur. A margin of safety (typically between 100 and 1,000, depending on the compound and the extent of its toxicological database) is included to protect sensitive members of the human population. The health advisories are developed for noncarcinogenic end points of toxicity. They can be specified for 1-d, 10-d, long-term (90 d to 1 yr), and lifetime exposure periods.

3.2.4.3 Maximum Contaminant Level Goals. As part of the process for developing final drinking water standards, EPA develops maximum contaminant level goals (MCLG) formerly known as recommended maximum contaminant level (RMCL). The MCLGs are nonenforceable health goals for drinking water that are set at a level representing "no known anticipated adverse effects on the health of persons, while allowing for an adequate margin of safety." For carcinogenic compounds, MCLGs are set at zero.

3.2.4.4 ICRP/NCRP Guidance. The International Council of Radiation Protection and the National Council on Radiation Protection have a guideline standard of 100 mrem/yr whole body dose of gamma radiation.

3.2.4.5 DOE Orders. Various DOE orders that set radiological dose and exposure limits and criteria are potential standards to which site remedial actions must comply.

3.2.4.6 Proposed Regulations. Ecology is currently developing cleanup regulations under the Model Toxic Control Act (WAC 173-340). These regulations, which include standards for air contaminants and for the remediation of contaminated soils and are expected to be fairly stringent. The standards probably will not cover radioactive substances.

EPA has issued an Advanced Notice of Proposed Rulemaking for radiation regulations in 40 CFR 193 and 40 CFR 194.1. These potential regulations are for low-level radioactive waste and residual radioactivity from demolition and decommissioning activities, respectively. At this time, EPA has not issued any proposed regulations. Ecology is currently reviewing draft ground water protection standards that are to be released for public comment in 1990.

3.2.5 Waivers

Federal law recognizes there may be instances in which ARARs cannot be met with respect to remedial actions onsite. Therefore, it identifies six circumstances under which ARARs may be waived. However, other statutory requirements, specifically, the requirement that remedies be protective of human health and the environment, cannot be waived. Waivers occur as the exception, not the rule. Waivers are appropriate if the following requirements are met.

- The remedial action selected is an interim remedy and only part of a total remedial action that will attain ARARs when completed.

- Compliance with ARARs at the site would result in greater risk to human health and the environment than alternative options.

- Compliance with ARARs is impracticable from a technical perspective.

- The remedial actions selected will attain an equivalent standard of performance, although ARARs are not met.

- With respect to state ARARs, the state has inconsistently applied ARARs in similar circumstances at other remedial actions within the state.

- In the case of fund-financed remedial actions, financial restrictions within the superfund program require fund-balancing so that satisfaction of ARARs at the site give way to the greater need for protection of public health and welfare, and the environment at other sites.

3.3 PRELIMINARY RISK ASSESSMENT

This section presents a preliminary evaluation of the current and future potential human health and environmental impacts associated with the 100-KR-4 operable unit. This initial evaluation, as part of the work planning process, serves several functions. First, it helps to focus the RI activities on those areas where current risks can be documented, or where future risks are possible. Second, this process can identify areas of uncertainty related to sources, pathways, and receptors that will need to be resolved during the RI in order to perform a quantitative and definitive risk assessment. Last, the initial assessment of potential impacts documents and provides, in part, the technical rationale for performing the RI/FS.

This section contains a discussion of the preliminary source-pathway-receptor model of the site. There is an evaluation of the environmental and toxicological characteristics of site contaminants and the preliminary identification of the contaminants of concern. The current and potential future endangerments that have been initially identified are also discussed.

3.3.1 Conceptual Exposure Pathway Model

Based on information presented thus far, a conceptual exposure pathway model has been developed that incorporates the potentially significant contaminant exposure pathways for the 100-KR-4 operable unit. The model was shown schematically in Figure 3-15.

The purpose of the conceptual pathway model is to present the possible unit-specific contaminant exposure pathways. During the RI, the conceptual model will be tested and refined in an iterative manner until the operable unit is sufficiently understood to support decisions regarding corrective measures. Risk assessment and sensitivity analysis are two methods of testing and refining the model. When the RI is conducted in this manner, the focus is kept on unit-specific objectives.

Each exposure pathway in the conceptual model must contain the following components:

- A contaminant source
- A contaminant release mechanism
- An environmental transport medium
- An exposure route
- A receptor.

Each of these components of the model is discussed in the following sections.

3.3.1.1 Sources. Primary contaminant sources in the 100-KR-4 operable unit include a variety of retention basins, septic tanks, cribs, pipelines, tanks, trenches, burial grounds, french drains, and outfall structures. After an initial release to the environment occurs, contaminants can be bound in soils and sediments before being slowly re-released. These media may serve as secondary contaminant sources.

3.3.1.2 Release Mechanisms. Release mechanisms can be divided into primary and secondary categories. Reactor purge water and process effluent at the 100-KR-4 operable unit are known to have infiltrated the soils surrounding the reactor basins and the process effluent transfer, treatment, and disposal facilities. Some of this effluent was also directly discharged to the Columbia River. Pipeline and retention basin leaks resulted in discharges to surface soils and the vadose zone. Wastes from the sanitary sewage system infiltrated into adjacent soils. As shown in Figure 3-15, the most significant primary release mechanism at the 100-K Area is infiltration. The most substantial contributions are from reactor purge water and process effluent. The most significant release mechanism from secondary sources is infiltration of contaminants from the vadose zone to the ground water.

3.3.1.3 Environmental Transport Media. Rainwater and snowmelt infiltrating from the ground surface transport contaminants in the unsaturated zone to the ground water. Although the average annual water infiltration in the 100-KR-4 operable unit is low, unusually heavy rainfall may cause containment movement in the unsaturated zone. After containments reach the ground water, they can be discharged to the Columbia River and transported downstream.

3.3.1.4 Exposure Routes. The following potential human health and environmental exposure routes result from the discharge of contaminated ground water to the Columbia River. The potential current human exposure routes at the 100-KR-1 operable unit include the following:

- Ingestion of Columbia River water
- Dermal contact with Columbia River water
- Ingestion of contaminated biota

- Ingestion of crops irrigated with contaminated Columbia River water

- Direct exposure of recreationalists to contaminated Columbia River water, and sediments and springs along the riverbank.

Similarly, the potential current environmental exposure pathways at 100-KR-4 operable unit include the following:

- Ingestion, by terrestrial organism, or contaminated Columbia River water or sediments, or contaminated biota

- Bioaccumulation of contaminants by aquatic organisms.

Potential future use includes unrestricted access to the Columbia River and should the DOE relinquish its control over the site, potential access to the ground water on site. In addition to the exposure pathways identified above, the following are the potential exposure pathways under an unrestricted future use scenario that are relevant to this ground water/surface water operable unit:

- Ingestion of contaminated ground water

- Ingestion of crops irrigated with contaminated ground water

- Ingestion of meat or milk produced using contaminated ground water

- Dermal contact with contaminated ground water.

Additional exposure pathways for an unrestricted future use are discussed in the 100-KR-1 operable unit work plan.

3.3.1.5 Receptors. A river pumphouse in the 100-D Area serves as a backup to supply drinking water to the 100-B/C, 100-D/DR, 100-K, 100-N, and 200 Areas. The total population that could potentially receive water from this portion of the river is approximately 3,000 persons. An additional 3,000 in the 300 Area (28 mi [45 km] downstream) receive drinking water from the Columbia River. The cities of Richland, Kennewick, and Pasco also use the river for domestic water. The populations served by these systems are estimated at 68,000 persons for Richland and Kennewick and 18,000 for Pasco. The closest withdrawal point is for Richland, which is 30 mi (48 km) downstream from the 100-K Area. All of these intakes are downstream of the 100-KR-4 operable unit.

Several irrigation intakes exist downstream from the operable unit, the nearest of which are located at Ringold and Taylor flats. These intakes primarily serve fruit orchards and irrigate forage crops such as alfalfa. River water withdrawn at Ringold Flats is used at a fish hatchery where steelhead trout and chinook salmon are raised.

Exposure to contaminated ground water within the boundaries of the 100-KR-4 operable unit will be more likely in the future if institutional control of the site is lost or abandoned. Should this happen, it is possible that future homes could be built atop a former waste disposal site. By digging into the surface soil to construct a house or drilling for a domestic water well exposure pathways could develop. The pathways could include the following:

- Inhalation of contaminated dust
- Direct gamma exposure
- Ingestion of contaminated well water
- Ingestion of contaminated food produced at the site
- Ingestion of contaminated soil by children.

During construction of a house at the site, contaminated soil could be brought to the surface. The individual could be exposed by inhaling contaminated dust during construction and after the house is completed. If radionuclides are present in the near-surface soil, the contaminated soil excavated during construction can also be the source of direct gamma exposures. It is possible that the individual would plant edible crops or raise edible animals that would forage in the contaminated surface soil. Plant uptake of contaminants from the soil can cause human exposures through the ingestion of contaminated vegetables, meat, and milk produced at the site.

3.3.1.6 Exposure Summary. The most significant primary source of contaminant releases in the 100-K Area are process effluent and contaminated water from 100-KE and 100-KW reactors. The most significant current contaminant release mechanism is water infiltration through contaminants in the unsaturated zone. Contaminants can eventually reach the ground water and be discharged to the Columbia River, where sediments and aquatic organisms may be exposed. Future human exposures may result if the area returns to private use after institutional control is lost.

3.3.2 Contaminants of Concern

Table 3-35 lists the preliminary contaminants of concern identified for the 100-KR-4 operable unit. This list is based on the types and quantities of wastes disposed at the unit and the contaminant characteristics.

3.3.3 Contaminant Characteristics

To evaluate the potential threat to public health and the environment from the 100-KR-4 operable unit, it is important to focus on the contaminants of greatest concern. Generally, the contaminants of greatest concern are those that are present in the largest quantities, highly mobile, toxic, or persistent in the environment. Ground water data provide information on contaminants that have reached the ground water.

3.3.3.1 Toxicity. Toxicity assessment considers the constituents that could be present in the environment after disposal. The known or potential chemical contaminants present in the environment are listed in Table 3-15. There is a possibility of increased toxicity as a result of mixing of contaminants, co-solvent and the effect of hot water (temperature).

Chromium and mercury can both pose a threat to human health and the environment. The primary drinking water standards for these contaminants are 50 $\mu g/L$ for (total) Cr^{+6} and 2 $\mu g/L$ for mercury. Chromium is classified by the EPA as a Group 1 carcinogen for inhalation exposure. However, Cr^{+6} has not been shown to be carcinogenic through ingestion. Chromium is toxic to aquatic organisms. Ambient water quality criteria for protection of fresh water organisms are 16 $\mu g/L$ for acute exposure and 11 $\mu g/L$ for chronic exposure. Mercury is toxic to both fish and humans because of biotransformation by microorganisms into highly toxic methyl mercury.

A primary drinking water standard for copper has not been established. The secondary standard for copper is 1,000 $\mu g/L$. Copper is toxic to aquatic organisms. The ambient water quality criteria for copper vary with the hardness of the water, but typical values are 12 $\mu g/L$ for acute exposure and 8 $\mu g/L$ for chronic exposure.

PCBs, which may be present in the 100-K Area, are long-lived in the environment, relatively immobile in soil, and are probably human carcinogens. No direct evidence of PCB contamination at the site was identified during the development of this work plan, but PCB transformers are assumed to have been used extensively in the 100-K Area.

Potential exposure to any of the identified radionuclides may be important from the standpoint of radiotoxicity. The dose response functions used by EPA to estimate radiation risks assume that any radionuclide exposure causes an incremental excess cancer risk. Consequently, in light of the additive effects of the various radionuclides, all of the isotopes in the previously mentioned table will be included in the baseline risk assessment.

3.3.3.2 Persistence. The environmentally persistent contaminants include Cr^{+6}, copper, mercury, PCBs, and radionuclides. Chromium and copper persist in the environment because they are not subject to chemical decomposition or biodegradation. Mercury may be biotransformed from its elemental state to the more toxic and more mobile methyl mercury. PCBs are very stable compounds that do not readily break down in the environment.

The environmental persistence of radionuclide depends in part on its half-life. The half-lives (years) of the radionuclides at the 100-K Area are shown in Table 3-35.

3.3.3.3 Mobility. The mobility of contaminants is dependent on the chemical form of the element, which is dependent on environmental conditions. Many metals have low mobility because they bind ironically to soils or form insoluble precipitates. However, Cr^{+6} and methyl mercury tend to be quite mobile. The negative ions, such as sulfate and chloride, are also mobile. PCBs also tend to bind to soil particles and are thus relatively immobile.

Metallic radionuclides such as uranium, plutonium, and cobalt tend to have low mobility. Because of their chemistry they bond tightly to soils and do not easily move through the soil column. However, if complexing agents are present, these and nonradioactive metals can form complexes that may not be retarded on soils as are the uncomplexed ionic forms. On the other hand, tritium and carbon, partly because of their involvement in the normal chemistry of life, can be highly mobile in the soil and ground water.

3.3.3.4 Bioaccumulation. Some contaminants can accumulate in plants and animals if absorbed or consumed by the organisms. Unitless bioconcentration factors for some of the contaminants that may be found in the 100-K Area are shown in Table 3-36.

3.3.4 Risk Quantification

Risk quantification will be used to access the potential risks, if any, to human health. Planning for the risk assessment is an integral component of the work plan and influences the data collection to be performed. Potential human exposure pathways will be determined for each component to be assessed in the study. The data needs for the field sampling program will be determined so that these data may be used to evaluate potential risks.

Using the EPA maximum contaminant level for each constituent to be assessed, or if none has been developed, using similar criteria, the potential risk to an exposed population will be evaluated. As a result of the risk assessment, the need for corrective measures will be determined.

As discussed in Section 3.3.1.4, humans may be exposed under both current and future use conditions. The extent and magnitude of chemical and radioactive contamination at the 100-KR-4 operable unit is not currently known; therefore, a quantitative chemical risk assessment is not possible at this time. Further quantification of hazardous substances such as but not limited to PCBs, mercury, chromium, and copper must be completed during the RI to allow the determination of human risks.

3.4 PRELIMINARY REMEDIAL ACTION OBJECTIVES AND ALTERNATIVES

This section develops preliminary remedial action objectives, general response actions, and a list of preliminary remedial action alternatives. This evaluation is based on available site data, the preliminary risk assessment, and the conceptual site model for the 100-K Area. The remedial action objectives may change or be refined as additional data are gathered and evaluated during the RI investigation, and they will be more fully developed and evaluated in the FS when additional and more specific information becomes available from the RI. This preliminary discussion of objectives and alternatives is intended to focus the RI so that the data needed for the FS are obtained.

3.4.1 Remedial Action Objectives

The primary objective of the RI/FS at the 100-KR-4 operable unit is to protect human health and the environment from harmful effects of the contaminants of concern at the site.

To focus the RI/FS toward specific goals, the following preliminary remedial action objectives have been identified for the 100-KR-4 operable unit.

- Prevent the current and potential discharge of ground water contaminants to the Columbia River at levels that result in unacceptable downstream environmental and public health risks or that do not achieve ARARs.
- Remediate the Columbia River sediments to concentrations that will not present unacceptable public health or environmental risks, or will not achieve ARARs.
- Remediate the ground water concentrations that achieve ARARs or to concentrations that will not present unacceptable public health risks (under either restricted or unrestricted future use of the site, depending on which is selected).
- Prevent or remediate the potential discharge of ground water in the form of springs at concentrations that would result in unacceptable environmental and public health risks or that do not achieve ARARs.

The preliminary list of contaminants of concern, the preliminary contaminant-specific ARARs, and the baseline risk assessment will serve as the basis for establishing target levels of remediation for each media.

3.4.2 General Response Action

General response actions represent broad classes of remedial measures that may be appropriate to achieve the remedial action objectives at the 100-KR-4 operable unit. Although general response actions and their associated technologies and process options can only be evaluated in general terms at this stage, their identification is useful in the development of the RI field sampling program. The following are the preliminary general response actions for the 100-KR-4 operable unit:

- No action
- Institutional controls
- Removal
- Treatment

- Disposal
- Monitoring.

A no alternative action will be included for evaluation in the FS as required by the National Contingency Plan [40 CFR 300.430(e)(1)(6)]. The no alternative action also provides a baseline for comparison with other response actions. Finally, a no alternative action may be appropriate for some sources or areas of contamination if the risk assessment determines that unacceptable public health risks are not presented by those sources or areas and that contaminant specific ARARs are not exceeded.

Institutional controls involve the use of physical barriers or access restrictions to reduce or eliminate public exposure to contamination. Considering the nature of the 100-KR-4 operable unit and the Hanford Site as a whole, institutional controls will likely be an integral part of remediation. Many access and use restrictions are already in place at the Hanford Site.

Removal of ground water will be considered as a means of changing or accelerating ground water flow directions and gradients. The ground water removed from the aquifer would then be contained or treated.

Onsite treatment of contaminated ground water through traditional unit processes would probably be applicable to all contaminants of concern except tritium to achieve contaminant-specific ARARs and levels dictated by the risk assessment.

Disposal will be required for any response action that involves onsite ground water or sediment treatment. Disposal will be necessary for the waste sludges generated by treatment processes. In addition, the discharge of treated or untreated ground water will be required.

Similar to institutional controls, ground water and surface water monitoring is not a stand-alone response action, but will likely be a component of some or all of the remedial alternatives. Monitoring will be necessary for postremediation evaluation of remedial action performance.

3.4.3 Remedial Technologies and Process Options

The next step in developing remedial action alternatives is the identification of remedial technologies and process options associated with each general response action. Figure 3-17 summarizes the technologies and process options available that may be applicable to the 100-KR-4 operable unit based on available data and present knowledge of the site. These technologies and process options will be developed and evaluated in detail as part of the FS.

3.4.4 Remedial Action Alternatives

Based on available site data and the preliminary identification of general response actions and remedial technologies, the following preliminary remedial action alternatives have been defined:

- A no action alternative (assumes long-term monitoring with contingency plans if releases or exposures increase)
- An alternative that would rely heavily on institutional controls and access controls, with limited use of containment to reduce the potential for human exposure to the contaminants
- An alternative that would slow the movement of contaminated ground water with a physical barrier, such as a grout curtain in the aquifer, or with a hydraulic barrier, created by injecting water downgradient of the contamination
- An alternative using removal, treatment, and disposal of contaminated sediments in the Columbia River
- An alternative using pumping and treating, or pumping, treating, and reinjecting to achieve ARARs and risk-based levels within a long time frame
- An alternative using pumping and treatment to achieve ARARs and risk-based levels within a short time frame.

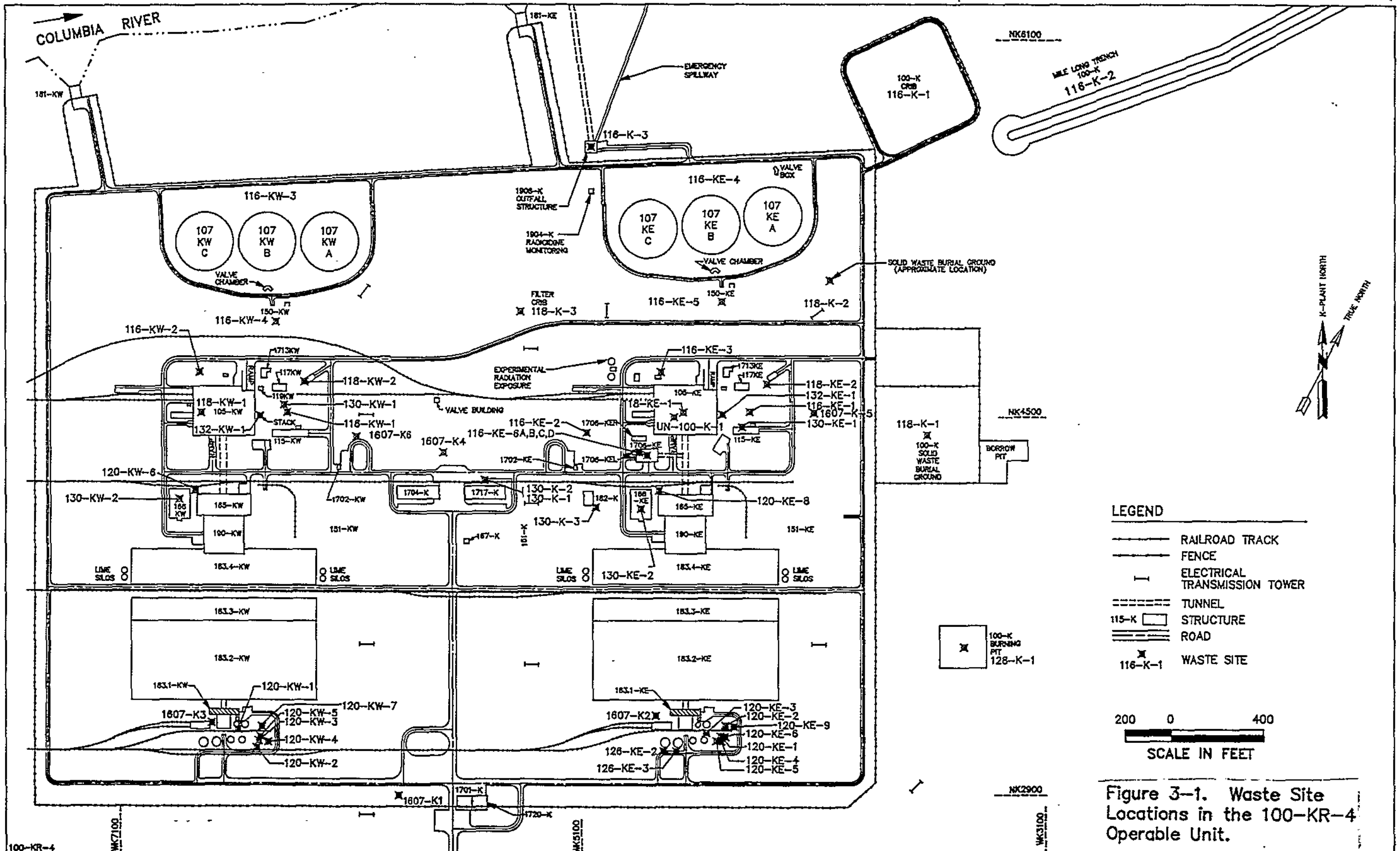

Figure 3-1. Waste Site Locations in the 100-KR-4 Operable Unit.

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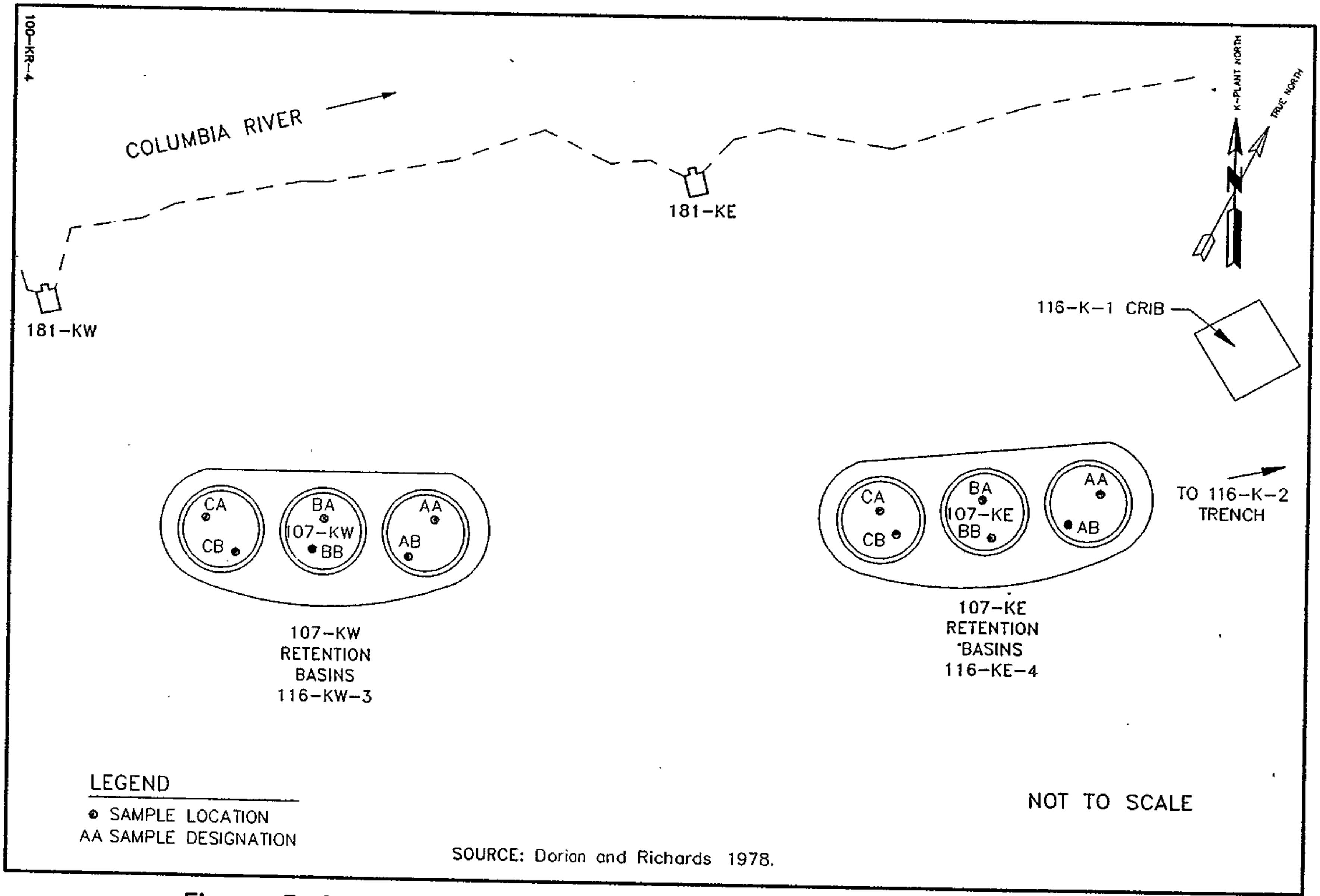

Figure 3-2. Sample Locations Inside the 107-K Retention Basins.

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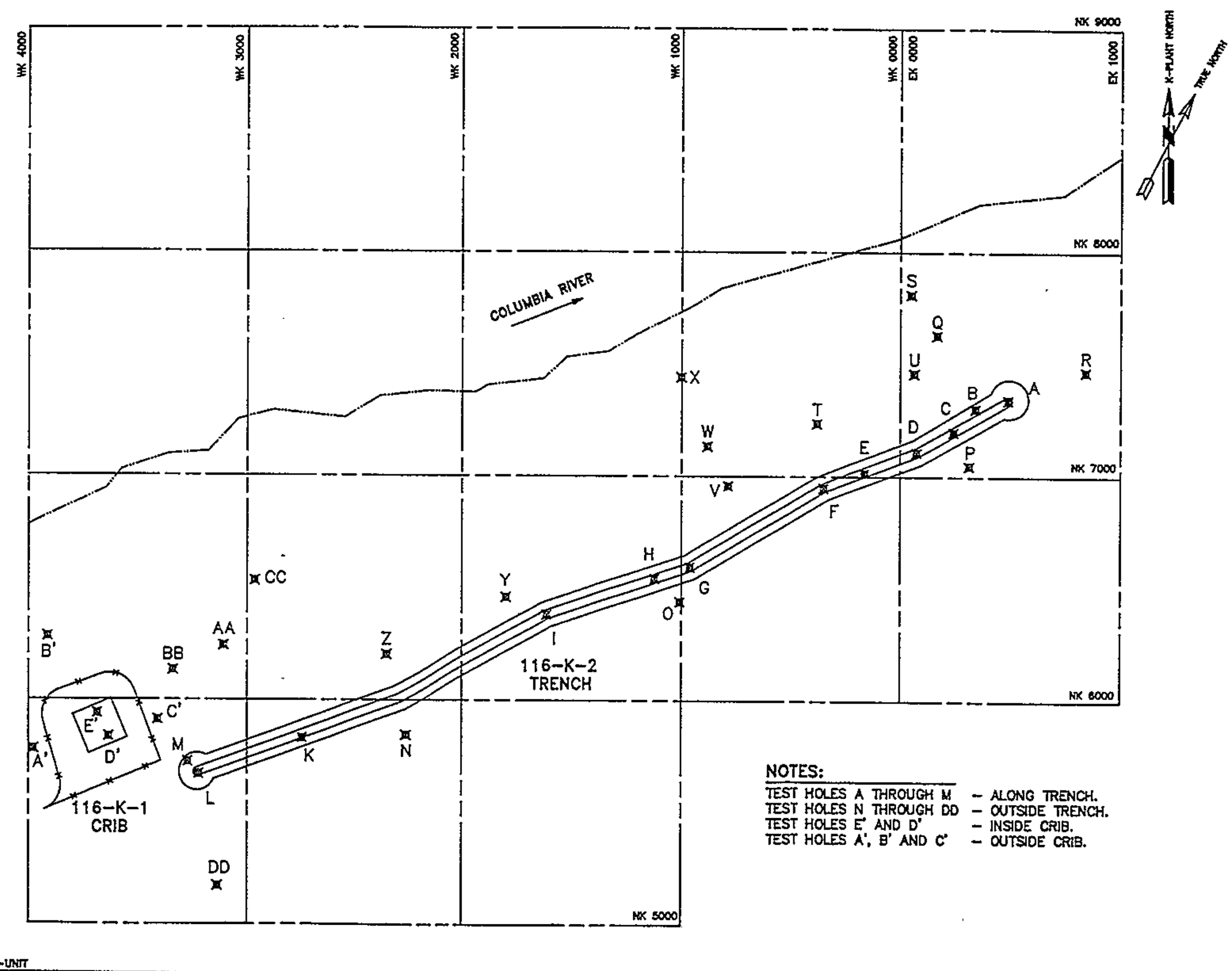

TRENCH AND CRIB SAMPLE HOLE DATA

TRENCH POINTS

HOLE	NORTH	EAST	ELEV (FT)
A	7344.07	493.73	427.15
B	7306.35	342.20	*
C	7200.94	241.06	428.11
D	7109.82	72.57	428.19
E	7017.50	–163.67	432.51
F	6950.14	–350.96	441.27
G	6596.24	–961.02	426.89
H	6544.75	–1122.38	427.59
I	6383.03	–1615.15	429.14
J	6007.33	–2313.53	434.30
K	5831.20	–2748.11	433.29
L	5670.02	–3221.84	433.40
M	5724.76	–3274.07	442.90
N	5845.30	–2275.39	442.25
O	6441.96	–1006.84	435.60
P	7049.12	313.20	434.71
Q	7632.32	165.32	411.90
R	7471.93	842.79	437.15
S	7613.41	46.70	405.61
T	7236.49	–381.24	416.17
U	7461.27	61.72	405.81
V	6957.16	–765.22	420.75
W	7133.90	–879.42	419.83
X	7443.60	–1001.93	414.46
Y	6460.41	–1799.47	426.48
Z	6204.70	–2359.54	423.84
AA	6242.68	–3108.46	404.53
BB	6133.12	–3342.05	409.00
CC	6532.96	–2965.27	398.18
DD	5170.29	–3137.24	450.96

CRIB POINTS

HOLE	NORTH	EAST	ELEV (FT)
A'	5782.15	–3978.20	421.77
B'	6263.34	–3912.69	404.50
C'	5914.15	–3411.34	430.05
D'	5837.66	–3635.41	430.17
E'	5941.70	–3687.14	420.86

* ELEVATION NOT REPORTED

LEGEND

H SAMPLE HOLE

FENCE

500 0 500

SCALE IN FEET

SOURCE: Dorian and Richards, 1978.

Figure 3-3. Location of Soil Samples from the 116-K-1 Crib and 116-K-2 Trench.

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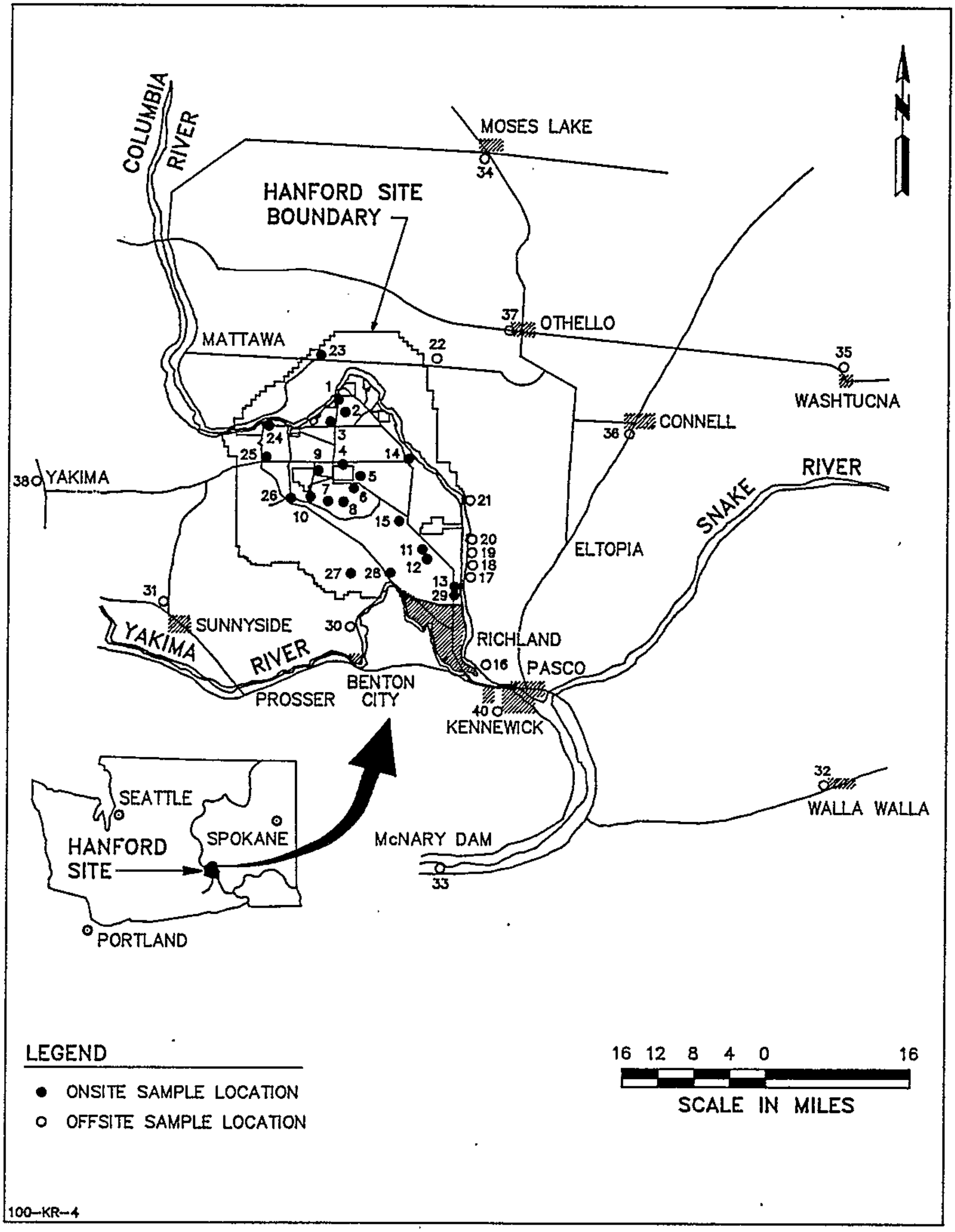

Figure 3-4. Onsite and Offsite Sampling Locations for Soil and Vegetation in 1988.

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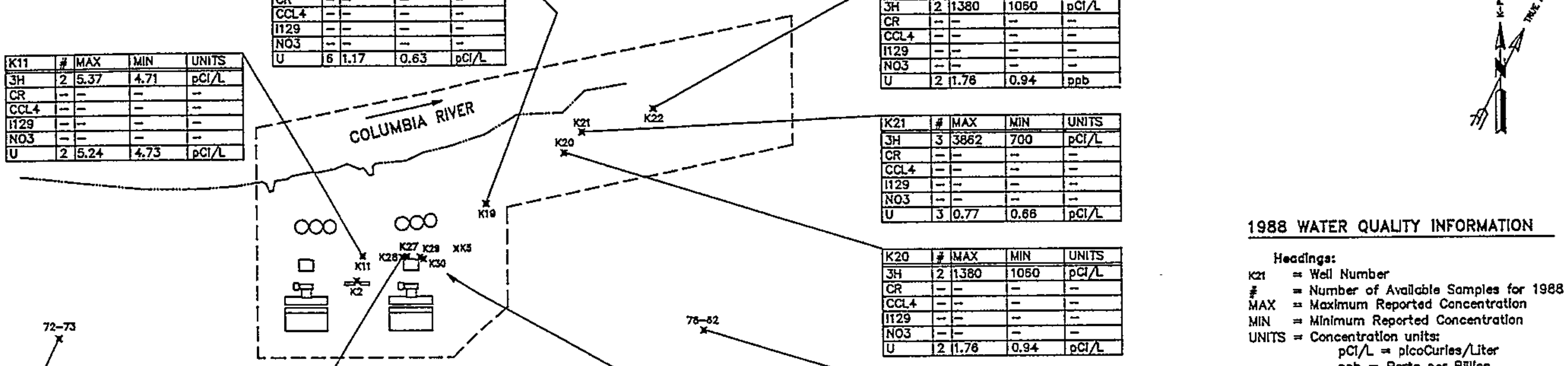
K19	#	MAX	MIN	UNITS
3H	6	4640	2840	pCi/L
CR	–	–	–	–
CCL4	–	–	–	–
I129	–	–	–	–
NO3	–	–	–	–
U	6	1.17	0.63	pCi/L

K11	#	MAX	MIN	UNITS
3H	2	5.37	4.71	pCi/L
CR	–	–	–	–
CCL4	–	–	–	–
I129	–	–	–	–
NO3	–	–	–	–
U	2	5.24	4.73	pCi/L

K22	#	MAX	MIN	UNITS
3H	2	1380	1060	pCi/L
CR	–	–	–	–
CCL4	–	–	–	–
I129	–	–	–	–
NO3	–	–	–	–
U	2	1.76	0.94	ppb

K21	#	MAX	MIN	UNITS
3H	3	3862	700	pCi/L
CR	–	–	–	–
CCL4	–	–	–	–
I129	–	–	–	–
NO3	–	–	–	–
U	3	0.77	0.66	pCi/L



K20	#	MAX	MIN	UNITS
3H	2	1380	1060	pCi/L
CR	–	–	–	–
CCL4	–	–	–	–
I129	–	–	–	–
NO3	–	–	–	–
U	2	1.76	0.94	pCi/L

72-73	#	MAX	MIN	UNITS
3H	2	1850	1670	pCi/L
CR	2	<10	<10	ppb
CCL4	2	<5	<5	ppb
I129	1	-0.009	–	pCi/L
NO3	4	4140	4030	ppb
U	–	–	–	–

K28	#	MAX	MIN	UNITS
3H	2	3290	3050	pCi/L
CR	–	–	–	–
CCL4	–	–	–	–
I129	–	–	–	–
NO3	–	–	–	–
U	2	3.77	3.44	pCi/L

78-62	#	MAX	MIN	UNITS
3H	–	–	–	–
CR	2	106	88	ppb
CCL4	2	<5	<5	ppb
I129	–	–	–	–
NO3	3	8480	8330	ppb
U	–	–	–	–

K27	#	MAX	MIN	UNITS
3H	2	2740	1850	pCi/L
CR	–	–	–	–
CCL4	–	–	–	–
I129	–	–	–	–
NO3	–	–	–	–
U	2	3.55	3.37	pCi/L

70-68	#	MAX	MIN	UNITS
3H	4	1850	1380	pCi/L
CR	3	<10	<10	ppb
CCL4	2	<5	<5	ppb
I129	–	–	–	–
NO3	7	3820	3710	ppb
U	4	1.26	0.63	pCi/L

73-61	#	MAX	MIN	UNITS
3H	4	183	-247	pCi/L
CR	3	17	12	ppb
CCL4	2	<5	<5	ppb
I129	1	0.03	–	pCi/L
NO3	7	9740	8300	ppb
U	4	1.61	1.23	pCi/L

K29	#	MAX	MIN	UNITS
3H	2	17000	10800	pCi/L
CR	–	–	–	–
CCL4	–	–	–	–
I129	–	–	–	–
NO3	–	–	–	–
U	2	1.78	1.76	pCi/L

66-64	#	MAX	MIN	UNITS
3H	4	6850	5870	pCi/L
CR	–	–	–	–
CCL4	–	–	–	–
I129	1	0.08	–	pCi/L
NO3	4	18100	15100	–
U	4	1.93	1.17	pCi/L

K30	#	MAX	MIN	UNITS
3H	–	1220000	1180000	pCi/L
CR	–	–	–	–
CCL4	–	–	–	–
I129	–	–	–	–
NO3	–	–	–	–
U	2	2.0	1.89	pCi/L

1988 WATER QUALITY INFORMATION

Headings:
K21 = Well Number
# = Number of Available Samples for 1988
MAX = Maximum Reported Concentration
MIN = Minimum Reported Concentration
UNITS = Concentration units:
pCi/L = picoCuries/Liter
ppb = Parts per Billion

Parameters:
3H = Tritium
CR = Chromium
CCL4 = Carbon Tetrachloride
I129 = Iodine – 129
NO3 = Nitrate
MU = Uranium

–(dash) = Indicates Analysis not Requested

LEGEND

K22A
x Well Location and Designation

0 1000 2000 4000
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Figure 3-5. Chemical Parameters in the 100-K Area Wells During 1988.

100-KR-4

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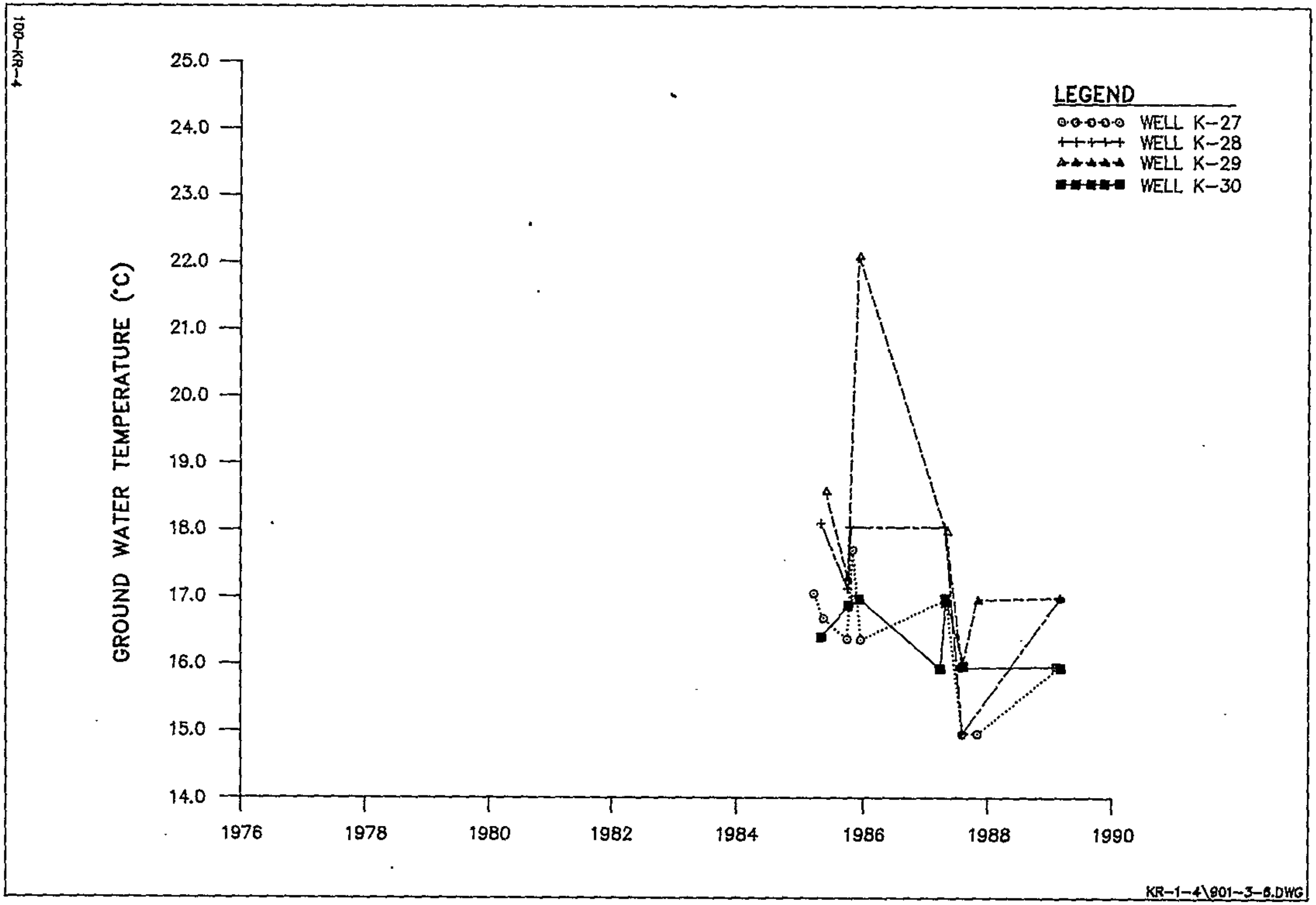

Figure 3-6. Ground Water Temperature vs. Time in 100-K Area. Wells K27, K28, K29, K30.

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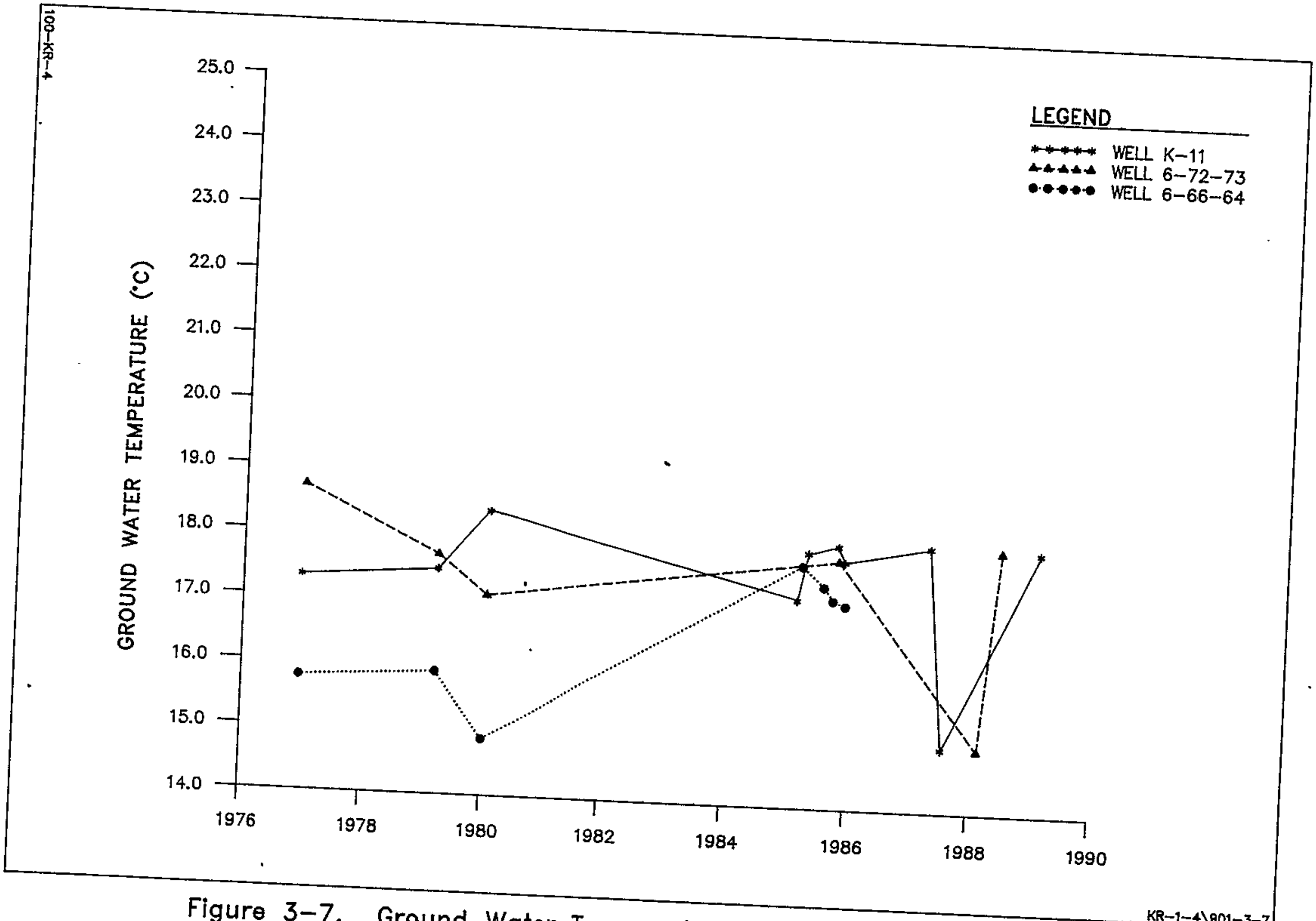

Figure 3-7. Ground Water Temperature vs. Time in 100-K Area Wells K11, 6-72-73, 6-66-64.

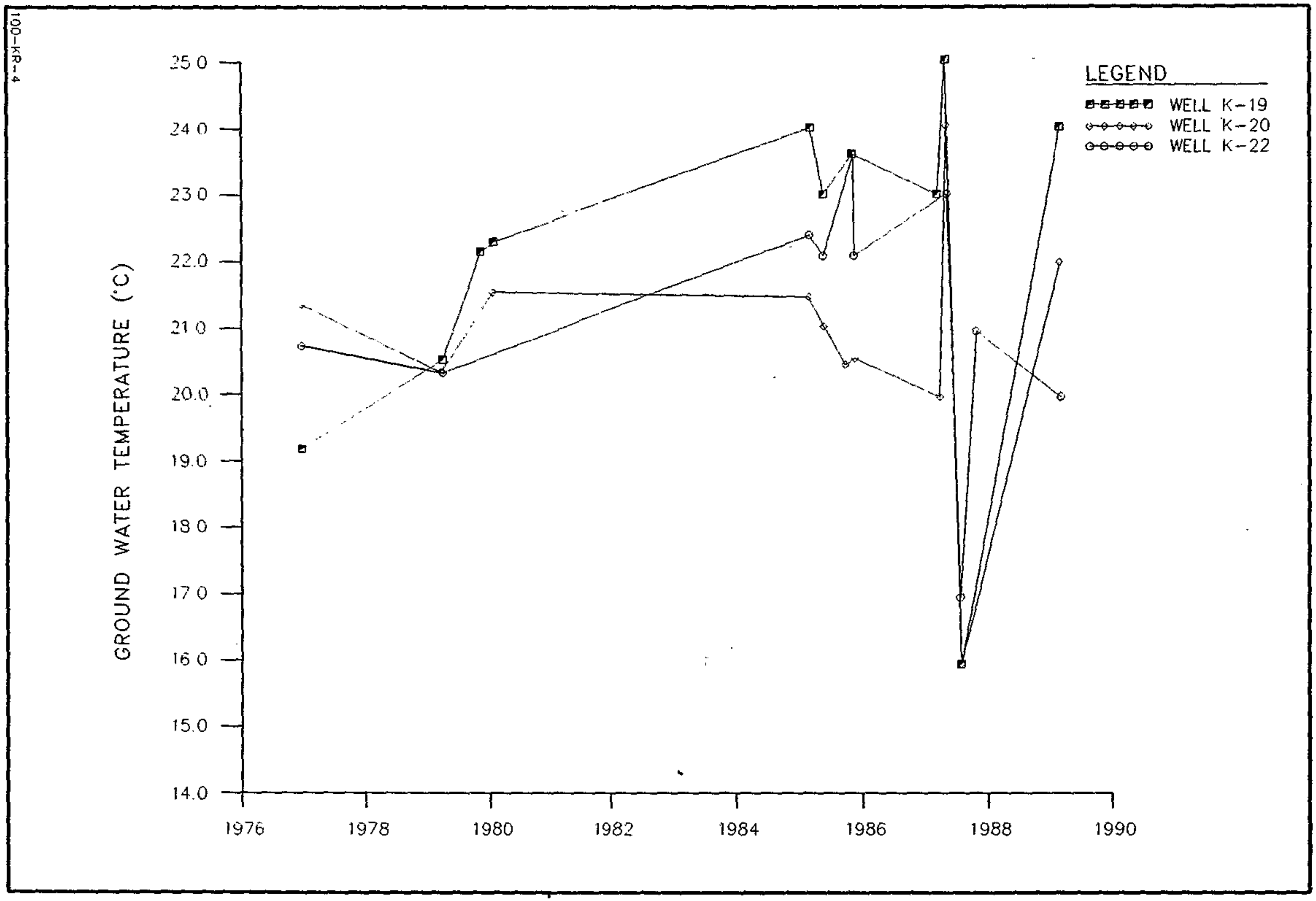

Figure 3-8. Ground Water Temperature vs. Time in 100-K Area Wells K19, K20, K22.

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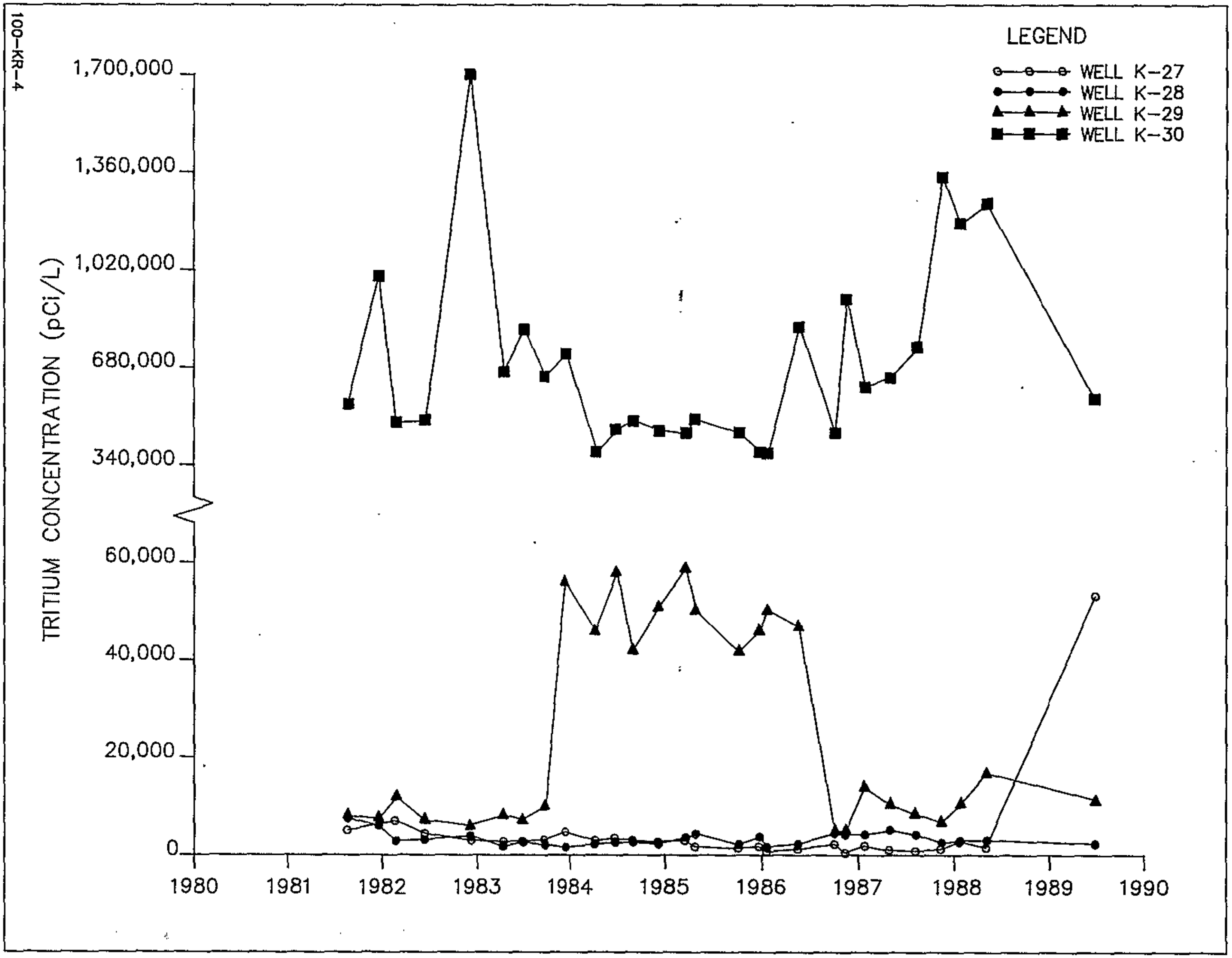

Figure 3-9. Tritium Concentration vs. Time in 100-K Area
Wells K-27, K-28, K-29, K-30.

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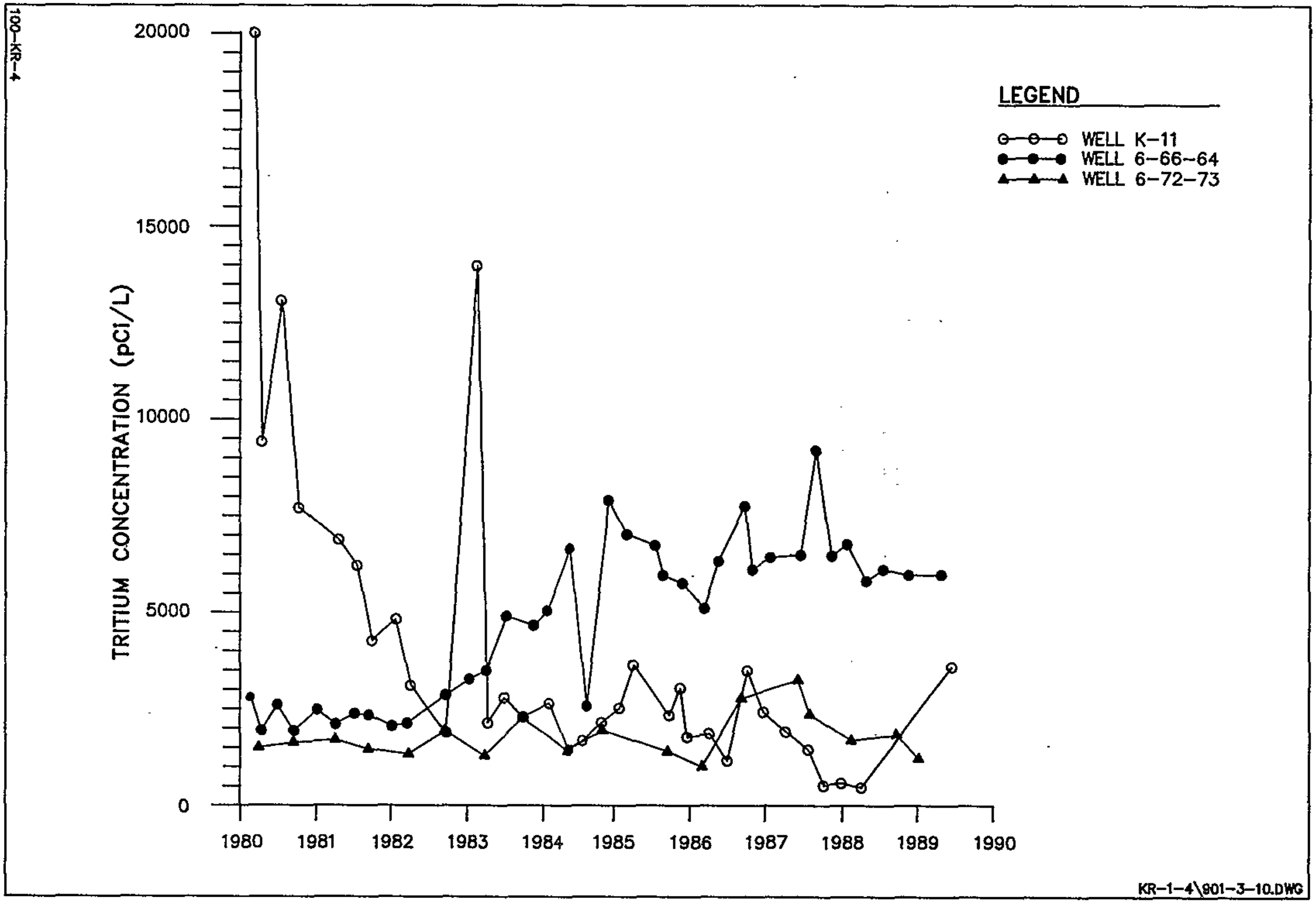

Figure 3-10. Tritium Concentration vs. Time in 100-K Area Wells K-11, 6-66-64, 6-72-73.

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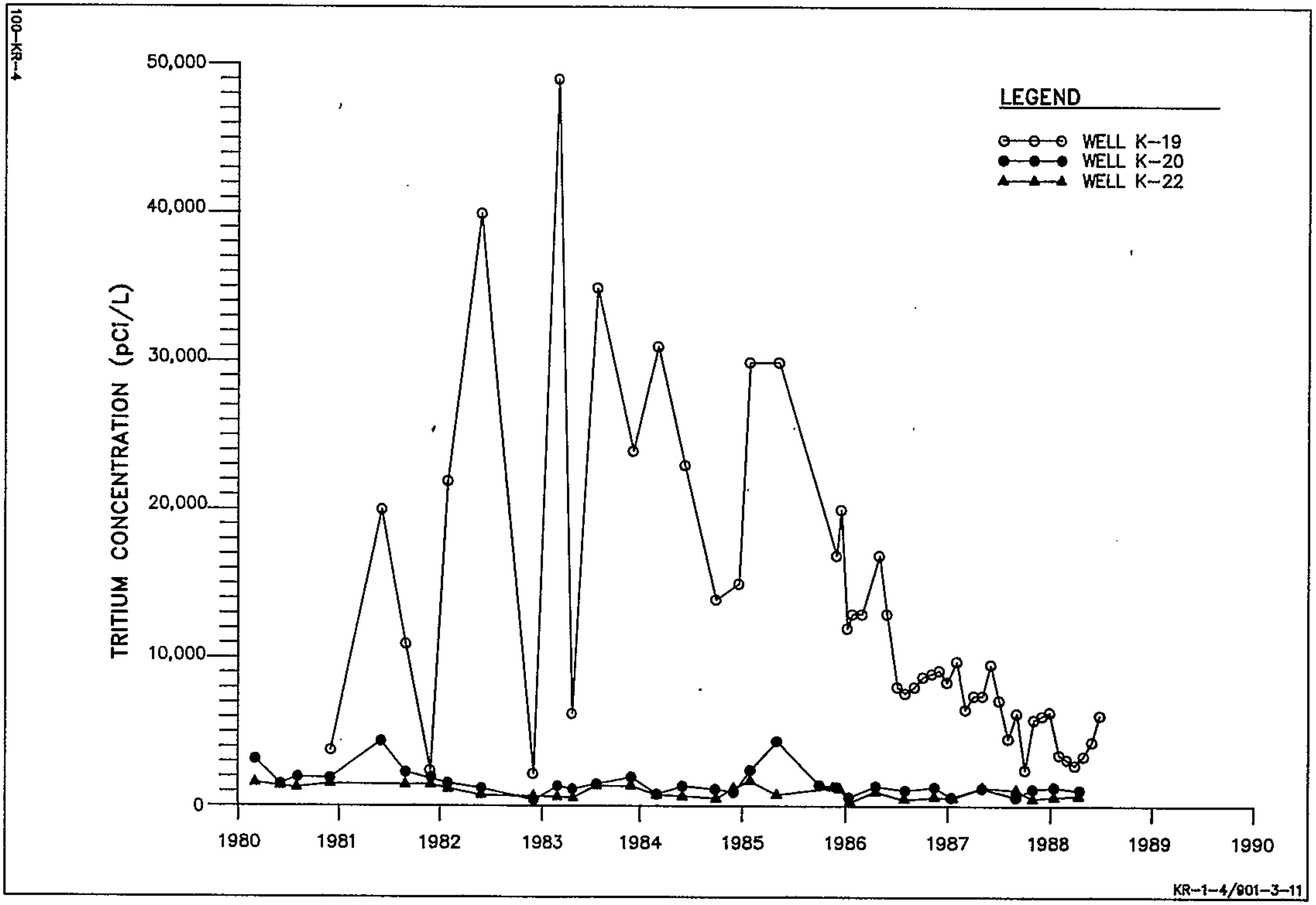

Figure 3-11. Tritium Concentration vs. Time in 100-K Area Wells K-19, K-20, K-22.

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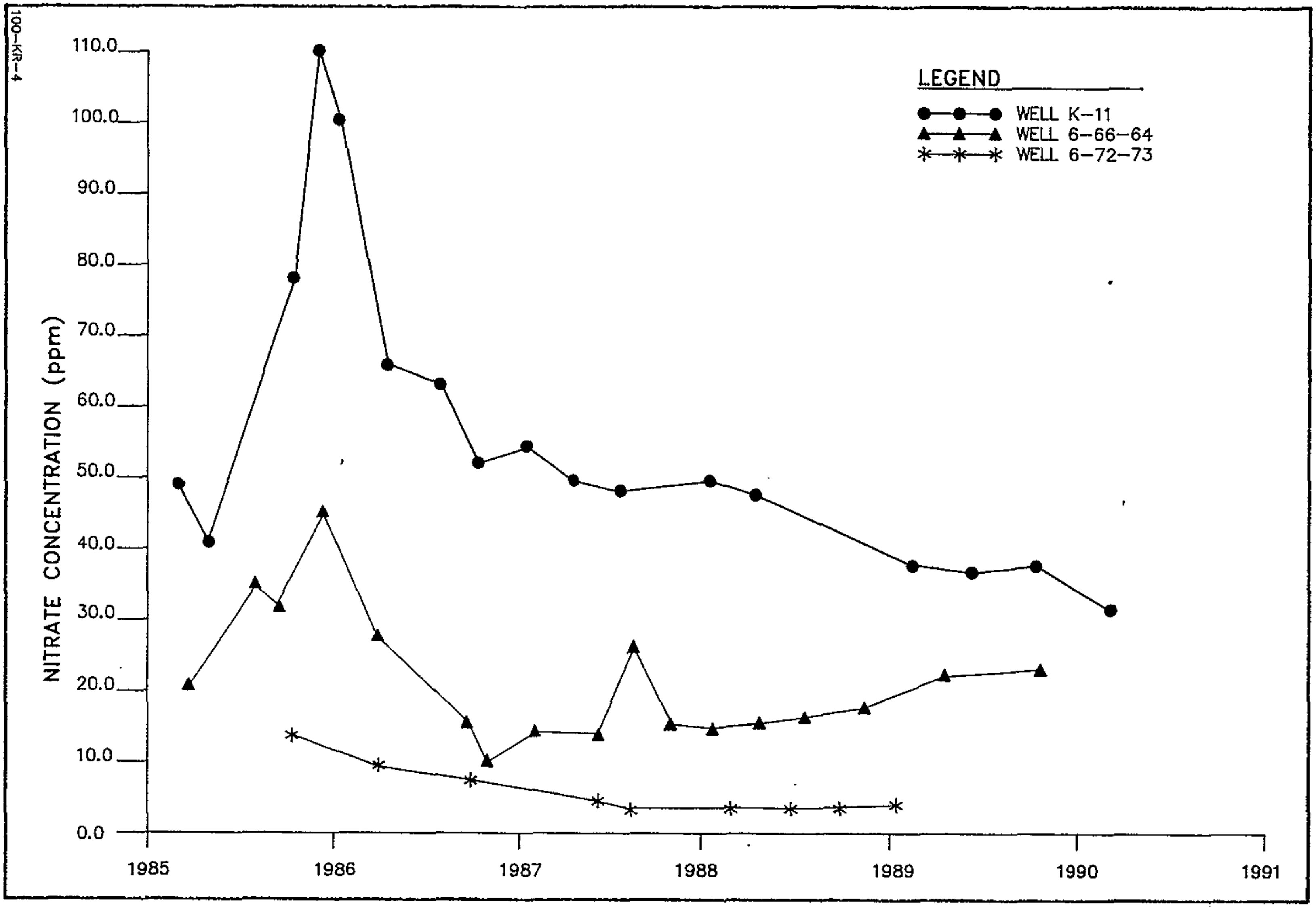

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Figure 3-12. Nitrate Concentration vs. Time in 100-K Area Wells K11, 6-66-64, 6-72-73.

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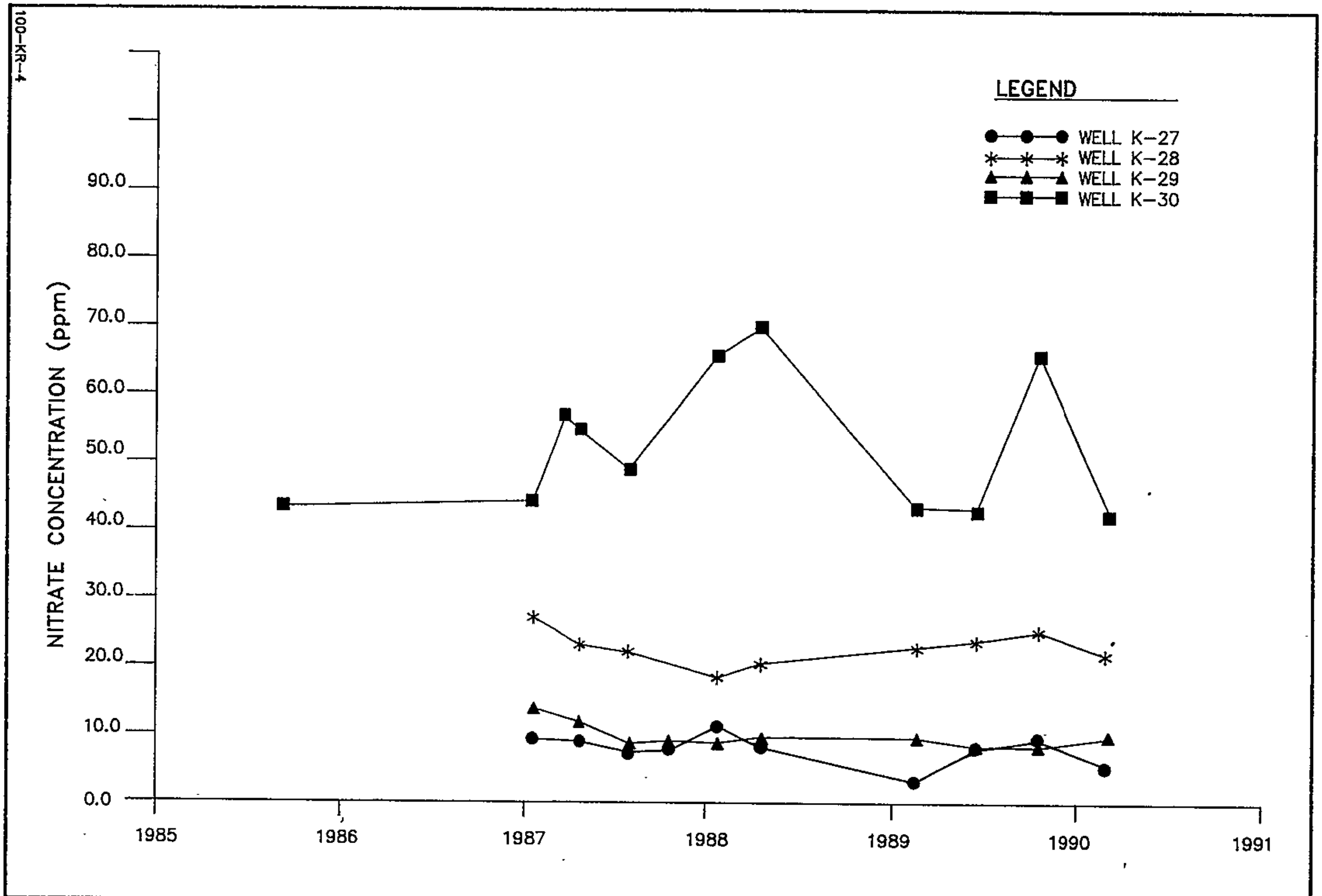

Figure 3-13. Nitrate Concentration vs. Time in 100-K Area Wells K27, K28, K29, K30.

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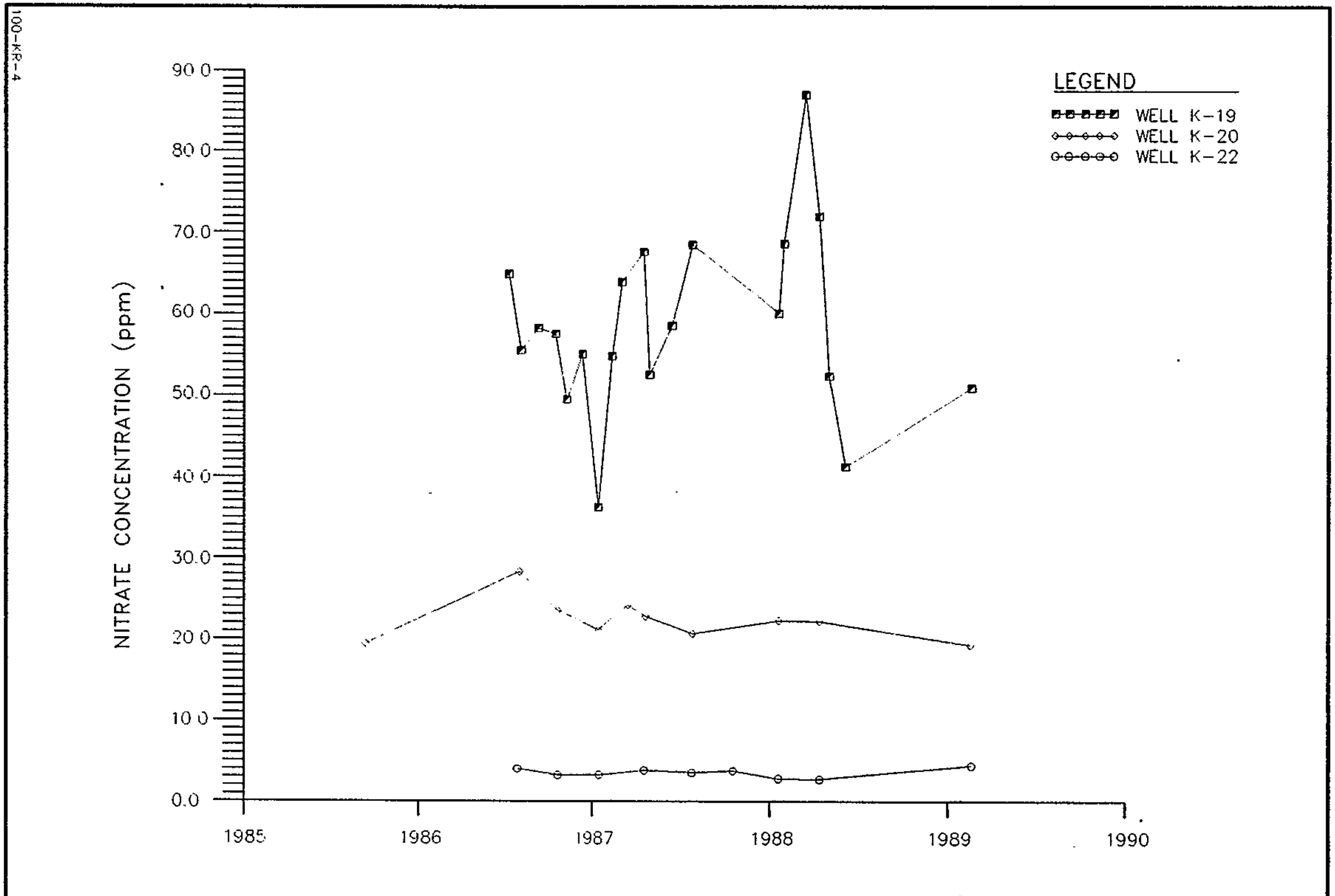

Figure 3-14. Nitrate Concentration vs. Time in 100-K Area Wells K19, K20, K22.

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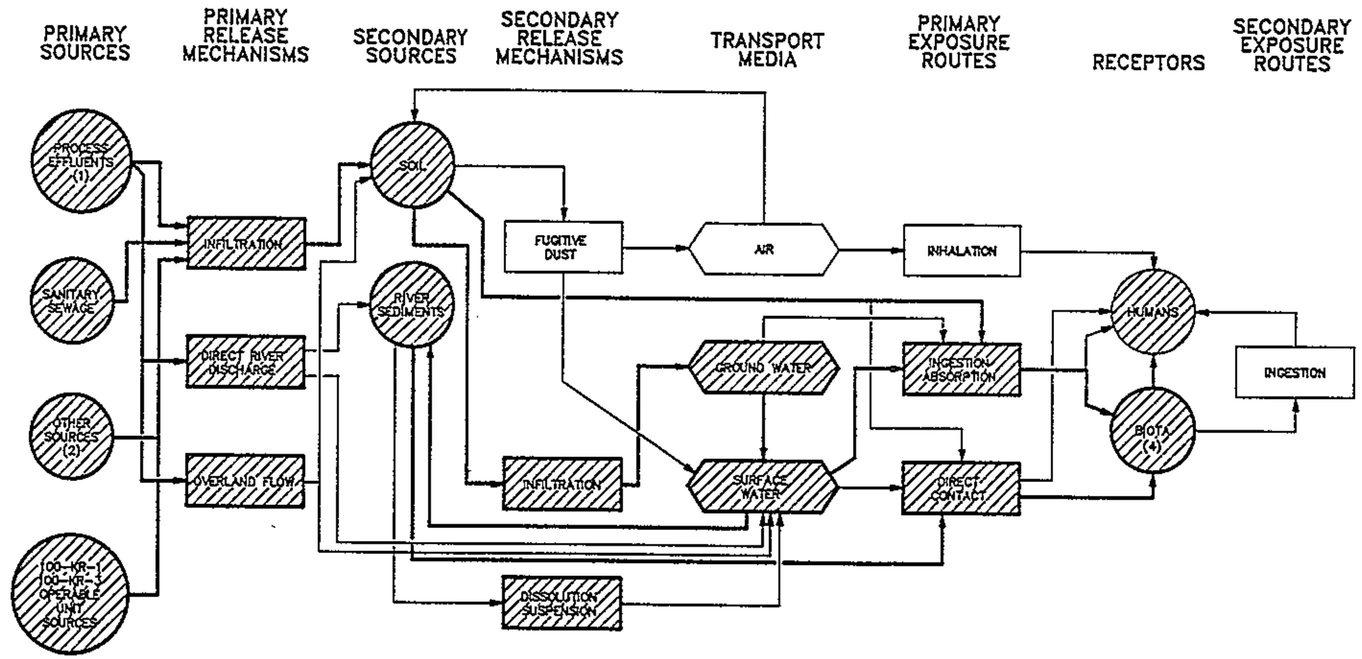

NOTES:

1. INCLUDES ALL FACILITIES THAT RECEIVED PROCESS EFFLUENTS, INCLUDING PIPELINES, BASINS, CRIBS, TRENCHES, FRENCH DRAINS AND OUTFALL STRUCTURE.S.
2. INCLUDES TANKS, TRANSFORMERS, SOLID WASTE LANDFILL, LEAKS AND OTHER SOURCES.
3. SHADED AREAS INDICATE SUBJECTS THAT ARE PERTINENT TO THE 100-KR-4 OPERABLE UNIT.
4. AQUATIC BIOTA INVESTIGATED IN 100-KR-4 OPERABLE UNIT.

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POTENTIAL EXPOSURE PATHWAY

POTENTIAL PRIMARY EXPOSURE PATHWAY

PRIMARY CONTAMINANT SOURCES AND KNOWN CONTAMINATED MEDIA

Figure 3-15. Site Conceptual Model – Contaminant Sources, Release Mechanisms, Environmental Transport Pathways, and Potential Receptors for 100-KR-4.

KR-1-4\901-3-15

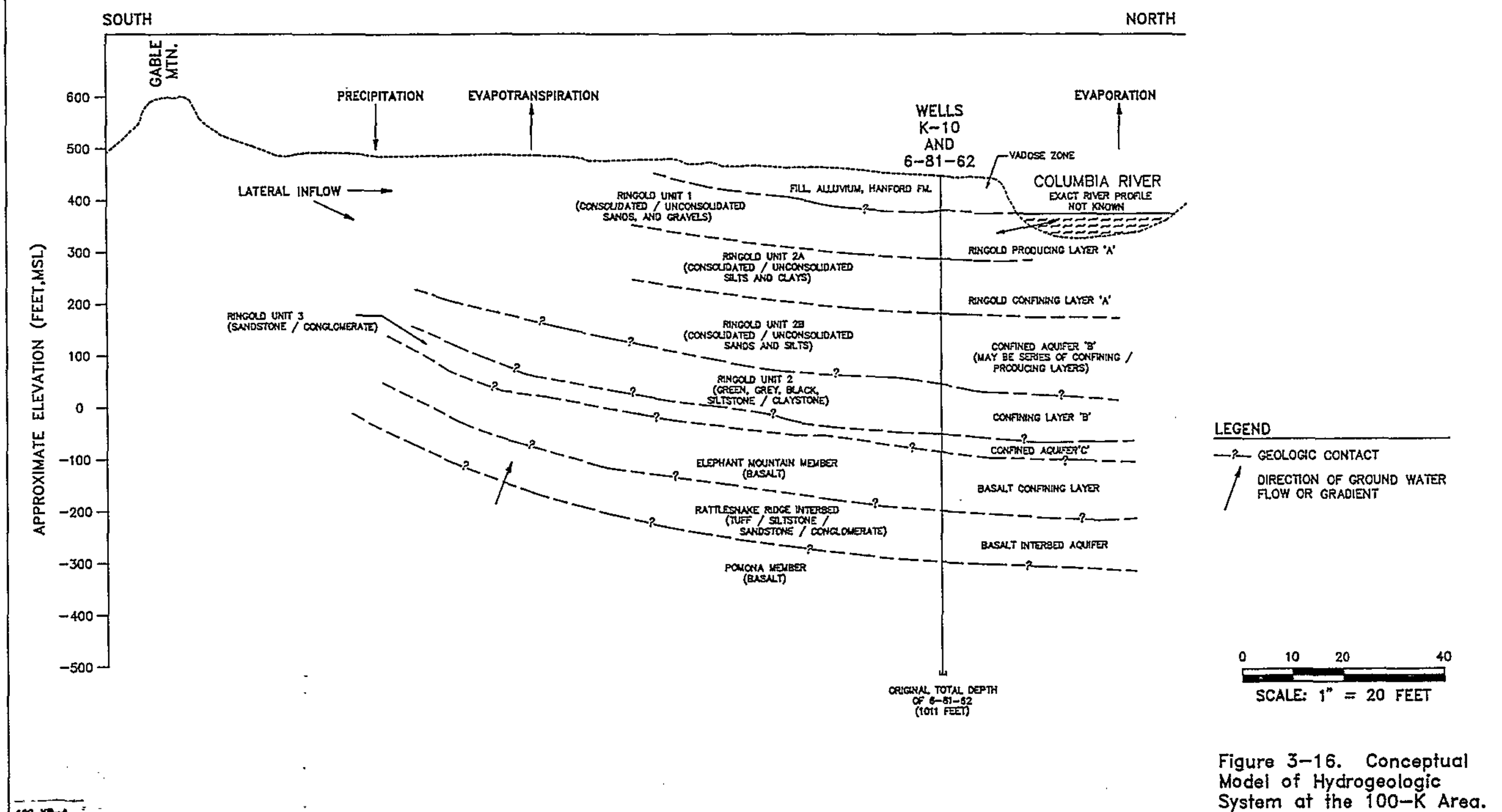

Figure 3-16. Conceptual Model of Hydrogeologic System at the 100-K Area.

KR-1-4\901-3-16.DWG

9 1 1 2 1 7 1 4 3 4

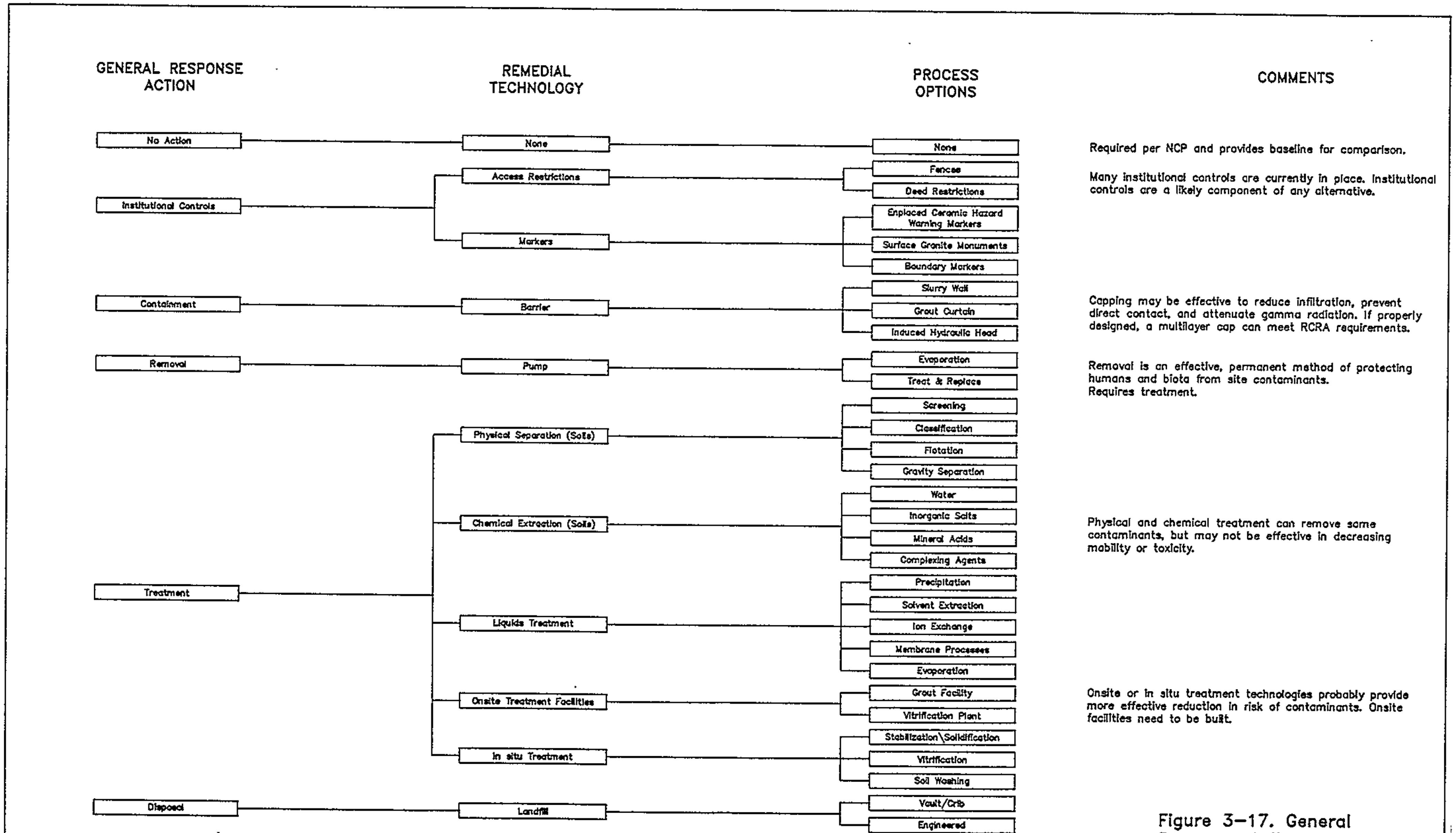

Figure 3-17. General Response Actions, Technologies and Process Options Available.

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Table 3-1. Profiles of Waste Sites and Structures Within the 100-K Area. (sheet 1 of 7)

Waste site/ waste source designation number	Associated facilities	Description	Years in service	Process stream received or handled	Waste characteristics
100-KR-1 Operable Unit					
116-K-1	100-K crib	Effluent crib	1955-1971	Direct discharge of cooling water effluent on one or two occasions of high activity from fuel element failure	46 Ci;10,000 cpm[1]; 40 kg sodium dichromate
116-K-2	100-K trench	Effluent trench	1955-1971	Direct discharge of cooling water effluent at times of high activity from fuel element failure. On a few occasions, high activity effluent was taken through the retention basins and then discharged	2100 Ci; 1,000+ - 12,000 cpm; misc. water treatment chemical additives
116-K-3	1908-K	Outfall structure NPDES Permit No. WA-00374-3	1955-present	Cooling water; discharge to river	No reported data
116-KE-4	107-KE	Three cooling water retention basins and adjacent area near tanks	1955-1971	Cooling water from 105-KE reactor	6.2 Ci soil 2,000 cpm - culvert area
116-KW-3	107-KW	Three cooling water retention basins and adjacent area near tanks	1955-1970	Cooling water from 105-KW reactor	3.9 Ci; soil 2,000 cpm - culvert area
100-KR-2 Operable Unit					
--	105-K reactors	Effluent discharge pipelines and valves	1955-1970	Cooling water from 105-K reactors to retention basins and outfall	No reported data
120-KW-6*	165-KE	Brine pit	1966-1971	Concrete 10 x 20 x 10 ft subsurface pits to mix salt brine for water softners	Unknown
120-KE-8*	165-KW	Brine pit	1966-1971	Concrete 10 x 20 x 20 ft subsurface pits to mix salt brine for water softeners	Unknown
128-K-2	Nonspecific	Burn site	1966-1971	Surface burning of chemicals and miscellaneous waste - later used for asbestos burial. Located west of operable units	Unknown

Table 3-1. Profiles of Waste Sites and Structures Within the 100-K Area. (sheet 2 of 7)

Waste site/ waste source designation number	Associated facilities	Description	Years in service	Process stream received or handled	Waste characteristics
a	165-KE	Glycol tank	1955-present	Ethylene glycol was used in heat exchangers on building space heaters	Unknown
a	165-KW	Glycol tank	1955-present	Ethylene glycol was used in heat exchangers on building space heaters	Unknown
a	165-KE	French drain	1955-1971	Located west of ethylene glycol tanks - use unknown	Unknown
a	165-KW	French drain	1955-1971	Located west of ethylene glycol tanks - use unknown	Unknown
a	Unknown	French drain	Unknown	Located west of and across the street from oil tank - use unknown	Unknown
a	Nonspecific	Experimental radiation exposure	estimated 1956-1960	Conducted fish development experiments in reactor effluent waters	Unknown
a	105-KE	Process drainage collection box	Unknown	Concrete 8 x 16 x 8 ft collection boxes for reactor building sumps and drains	Unknown
a	105-KW	Process drainage collection box	Unknown	Concrete 8 x 16 x 8 ft collection boxes for reactor building sumps and drains	Unknown
a	105-KE	Catch tank	1975-present	Concrete and steel silo, 35 ft deep used to catch sub-basin drainage	Unknown
a	105-KW	Catch tank	1975-present	Concrete and steel silo, 35 ft deep used to catch sub-basin drainage	Unknown
a	105-KE	Waste tank	1975-present	A 9 ft x 40 ft PVC-lined steel storage tank 24 ft north of buildings	Unknown
a	105-KW	Waste tank	1975-present	A 9 ft x 40 ft PVC-lined steel storage tank 24 ft north of buildings	Unknown
a	105-KE	C sump	1975-present	Concrete sumps 7.5 x 4.6 x 12 ft to collect overflow drainage at reactor basin sump	Unknown

Table 3-1. Profiles of Waste Sites and Structures Within the 100-K Area. (sheet 3 of 7)

Waste site/ waste source designation number	Associated facilities	Description	Years in service	Process stream received or handled	Waste characteristics
a	105-KW	C sump	1975-present	Concrete sumps 7.5 x 4.6 x 12 ft to collect overflow drainage at reactor basin sump	Unknown
116-KE-1	115-KE	Percolation crib (40 x 40 x 26 ft)	1955-1971	Condensate and other gas wastes from reactor gas purification systems	Average beta-gamma 4.5 x 10^5 pCi/g (1981) total Ci < 240
116-KE-2	1706-KER	Percolation crib (16 x 16 x 32 ft)	1955-1971	From 1957 to 1964, site received wastes from cleanup columns in 1706-KER loop	Average beta 4.3 x 10^3 pCi/g (1981) 10,000-kg sodium hydroxide total 38 Ci
116-KE-3	105-KE fuel storage basin	Percolation french drain	1955-1971	Site received subdrainage from the 105-KE fuel storage subdrainage	No reported data
116-KE-5[b]	150-KE	Heat exchangers	1955-1971	Trace radioactive contamination remain in piping	No reported data
116-KE-6(A-D)[b]	1706-KER	Storage tanks	1986-present	Mixed waste	No reported data
116-KW-1	115-KW	Percolation crib (40 x 40 x 26 ft)	1955-1971	Site received condensate and other wastewater from reactor gas purification system	Beta-gamma - 4.5 x 10^5 pCi/g Pu-239/240 - 2.1 pCi/g total 240 Ci
116-KW-2	105-KW fuel storage basin	Percolation french drain (10 ft dia x 39 ft)	1955-1970	Low-level waste from subdrainage out of 105-KW storage basin	No reported data
116-KW-4[b]	150-KW	Heat exchangers	1955-1970	Trace of radioactive contamination remain in piping	No reported data
118-K-1	100-K	Burial ground	1955-1975	Mixed solid waste; contains numerous trenches	Total 14,000 Ci
118-K-2	107-K	Burial ground		Sludge from 107-K retention basin cleanup	No reported data
118-K-3	1706-KE	Filter crib		Effluent from cooling loop studies and other R&D in 1706-KE	Reported to be nonradioactive

Table 3-1. Profiles of Waste Sites and Structures Within the 100-K Area. (sheet 4 of 7)

Waste site/ waste source designation number	Associated facilities	Description	Years in service	Process stream received or handled	Waste characteristics
118-KE-1[b]	105-KE	Reactor building	1955-1971	Mixed waste, some highly radioactive; this unit consists of (1) reactor block; (2) irradiated fuel storage basin; (3) contaminated portions of KE-Reactor building 58,000 Ci of radionuclides, 167T Pb, 25,000 ft^3 of asbestos	
118-KE-2[b]	105-KE	KE thimble cave	1955-1971	Used for storing radioactive rod tips pending later disposal; trace radionuclides remain	No reported data
118-KW-1	105-KW	KW reactor building	1955-1970	(1) reactor block; (2) irradiated fuel storage basins; (3) contaminated portions of 105-KW building, 51,000 Ci, 155T, Pb, 25,000 ft^3 of asbestos	
118-KW-2	105-KW	KW thimble cave	1955-present	Used for storing radioactive rod tips; currently 4 rods plus other rod removal components; radiation at entrance with open door is 50 mrad/h	No reported data
130-K-1	117-K	Storage tank		Tank is filled with water and trace gasoline; soil column not contaminated. Tank removed in 1989	No reported data
130-K-2	117-K	Storage tank	1955-1972	A small pool of motor oil remains in this tank; soil column not contaminated. Tank removed in 1989	No reported data
130-KE-1	115-KE	Diesel fuel storage tank 2,000 gal	1955-1971	Fuel oil tank empty	No reported data

Table 3-1. Profiles of Waste Sites and Structures Within the 100-K Area. (sheet 5 of 7)

Waste site/ waste source designation number	Associated facilities	Description	Years in service	Process stream received or handled	Waste characteristics
130-KE-2	165-KE	Fuel oil storage bunkers 1,650,000 gal capacity	1955-1971	2,000 gal remain in concentrate tank; used for firing 16 KE boilers	No reported data
130-KW-1	115-KW	Diesel fuel storage tanks 2,000 gal capacity	1955-1970	Diesel, empty tank	Nonhazardous
130-KW-2	165-KW	Fuel storage tank	1955-1970	Identical to 130-KE-2	No reported data
132-KE-1[b]	105-KE	Stack; top 125 ft of 300 ft stack demolished and remains in center of stack	1955-1971	Low-level waste	Decontaminated prior to demolition of top 125 ft
132-KW-1[b]	105-KW	Stack	1955-1970	Identical to 132-KE-1	Decontaminated prior to demolition of top 125 ft
1607-K4/124-KZ	1704-K, 1717-K	Septic tank	1955-present	Receives sanitary sewage from offices and maintenance shop; flow rate of 1,750 gpd	No reported data
1607-K6/124-KW-1	105-KW, 115-KW, 165-KW	Septic tank	1955-present	Receives sanitary sewage from KW reactor building, 115-KW gas recirculation building and power house; flow estimated at 100 gpd	No reported data
UN-100-K-1	105-KE	Leak from pickup chute area	N/A	Mixed liquid waste from KE reactor storage basin; first detected during conversion to 100-N fuel storage in 1973 - then 4 gph in April 1979 450 gph rate detected	No reported data
<u>100-KR-3 Operable Unit</u>					
120-KE-1	183.1-KE	Drywell 4 x 4 x 6 ft	1955-1971	Sulfuric acid sludge from the sulfuric acid storage tanks	200-kg mercury
120-KE-2	183-1-KE	Percolation french drain; 3-ft dia x 3 ft	1955-1971	Sulfuric acid sludge from the sulfuric acid storage tanks	200-kg mercury
120-KE-3		Percolation trench (40 x 3 x 3 ft)	1955-1970	Sulfuric acid sludge form the sulfuric acid storage tanks	700-kg mercury

Table 3-1. Profiles of Waste Sites and Structures Within the 100-K Area. (sheet 6 of 7)

Waste site/ waste source designation number	Associated facilities	Description	Years in service	Process stream received or handled	Waste characteristics
120-KW-1	183.1-KW	Drywell; 4 x 4 x 4 ft	1955-1970	Sulfuric acid sludge from the sulfuric acid storage tanks	200-kg mercury
120-KW-2	183.1-KW	Percolation french drain; 3-ft dia x 3 ft	1955-1970	Sulfuric acid sludge from the sulfuric acid storage tanks	200-kg mercury
120-KW-5	183.1-KW	Sodium dichromate storage tank; removed in 1970; concrete base and piping remains	1955-1970	No documented releases	Evidence of residual dichromate in the soil
120-KE-6	183.1-KE	Solidum dichromate storage tank removed in 1971; concrete base and piping remains	1955-1971	No documented releases	Evidence of residual dichromate in the soil
128-K-1	100-K pit	Burning pit 100 x 100 x 10 ft	1955-1971	Used for the disposal of nonradioactive combustible waste such as paint, office and chemical solvents	No reported data
130-K-3	182-K	Two drained 17,000 gal diesel storage tanks	1955-1972	Diesel fuel	No reported data
1607-K-1	1701-K, 1720-K	Septic tank	1955-present	Sanitary sewage from the 1701-K and 1720-K buildings; estimated daily flow of 350 gal	No reported data
1607-K-2	183-KE	Septic tank	1955-present	Sanitary sewage from the 183-KW water treatment plan; flow unknown	No reported data
1607-K-3	183-KW	Septic tank	1955-1970	Sanitary sewage; waste amount unknown	No reported data
1607-K-5	1706-KER, 1706-K, 165-KE, 105-KE, 115-KE	Septic tank	1955-present	Sanitary sewage; estimated daily flow is 700 gal	No reported data
120-KE-4[b]	183.1-KE	Sulfuric acid storage tank (10,109 gal) tank has been drained and neutralized	1955-1971	supply pipe from tank leaked to 183-1-building at NE corner	Leaked unknown quantity of sulfuric acid
120-KE-5[b]	183.1-KE	Sulfuric acid storage tank (10,109 gal) tank has been drained and neutralized	1955-1971	No leakage reported	No leakage reported

Table 3-1. Profiles of Waste Sites and Structures Within the 100-K Area. (sheet 7 of 7)

Waste site/ waste source designation number	Associated facilities	Description	Years in service	Process stream received or handled	Waste characteristics
120-KW-3[b]	183.1-KW	10,109 gal sulfuric acid storage tank; tank has been drained and neutralized	1955-1970	Supply pipe from tank to 183-1 building leaked	Leaked unknown quantity of sulfuric acid
120-KW-4[b]	183.1-KW	10,109 gal sulfuric acid storage tank; tank has been drained and neutralized	1955-1970	No leakage reported	No leakage reported
126-KE-2[b]	183.1-KE	180,000 gal alum storage tank	1955-1971	Currently being used to store purge water from monitoring wells or alum for processing water	Nonhazardous waste
126-KE-3[b]	183.1-KE	180,000 gal alum storage tank	1955-1971	Currently being used to store purge water from monitoring wells or alum for processing water	Nonhazardous waste

[a]No number assigned
[b]Building structure or other waste source located within the operable unit
Sources: AEC-GE, 1964, WHC 1990b

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Table 3-2. Summary of Radionuclide Inventories in the 107-K Retention Basins in 1976 (Dorian and Richards 1978).

Samples	107-KE (3 tanks)	107-KW (3 tanks)
Sludge	0.35 Ci	0.51 Ci
Soil fill less sludge	0.15 Ci	0.48 Ci

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Table 3-3. Radionuclide Concentrations in Soil Samples Inside the 107-K Retention Basins (Dorian and Richards 1978). (sheet 1 of 2)

Sample number/ depth (ft)	^{238}Pu	$^{239/240}Pu$	^{90}Sr	^{3}H	P-11/+ Scaler cpm	^{52}Eu	^{60}Co	^{154}Eu	^{134}Cs	^{137}Cs	^{155}Eu	U	^{63}Ni
107-KE Basins Concentration (pCi/g)													
AA 0	*	*	$6.7X10^{-2}$	$2.1x10^{0}$	<200/40	$6.9x10^{-1}$	$1.1x10^{-1}$	$4.9x10^{-1}$	$9.7x10^{-2}$	$1.6x10^{-1}$	$1.6x10^{0}$		
3	*	$1.9x10^{-1}$	$6.0x10^{0}$	$2.1x10^{0}$	<200/160	$6.6x10^{1}$	$2.0x10^{1}$	$2.4x10^{1}$	*	$1.6x10^{0}$	$5.3x10^{0}$		
AB 0			$7.6x10^{-2}$		<200/20	$4.2x10^{0}$	$1.8x10^{-1}$	$1.3x10^{0}$	$3.1x10^{-2}$	$1.3x10^{-1}$	$3.4x10^{-1}$		
2	*	$1.8x10^{-1}$	$6.9x10^{-1}$	$7.6x10^{-1}$	<200/200	$1.0x10^{2}$	$8.4x10^{0}$	$3.7x10^{1}$	*	$1.9x10^{-1}$	$4.4x10^{0}$		
BA 1			$1.6x10^{-1}$		<200/30	$3.4x10^{-1}$	$1.2x10^{-1}$	*	$8.8x10^{-2}$	$1.4x10^{-1}$	$1.7x10^{0}$		
1-1/2	$6.2x10^{-1}$	$4.6x10^{0}$	$1.6x10^{-1}$	*	<200/150	$6.5x10^{1}$	$8.0x10^{0}$	$3.2x10^{1}$	$7.3x10^{-1}$	$1.7x10^{0}$	$1.5x10^{1}$		
BB 1-1/2	*	*	$1.9x10^{-1}$	*	<200/150	$6.4x10^{1}$	$5.2x10^{0}$	$2.5x10^{1}$	*	$3.3x10^{-1}$	$3.9x10^{0}$		
CA 0	*	*	$3.7x10^{-2}$		<200/20	$1.6x10^{0}$	$1.4x10^{-1}$	$8.5x10^{-1}$	*	$1.4x10^{-1}$	$1.6x10^{0}$		
2	*	$9.8x10^{-1}$	$1.3x10^{1}$	$6.0x10^{0}$	800	$1.8x10^{2}$	$1.8x10^{2}$	$7.7x10^{1}$	*	$6.2x10^{0}$	$1.1x10^{1}$		
CB 0			$3.6x10^{-2}$		400	$1.2x10^{1}$	$3.9x10^{-1}$	$4.8x10^{0}$	*	$9.4x10^{-2}$	$1.5x10^{0}$		
1	*	*	$3.2x10^{-1}$		400	$3.5x10^{0}$	$2.6x10^{0}$	$2.3x10^{0}$	*	$7.8x10^{-2}$	$6.3x10^{-1}$		
2			$9.2x10^{-2}$		<200/20	$3.8x10^{0}$	$3.8x10^{0}$	$2.7x10^{0}$	*	$1.5x10^{-1}$	$2.7x10^{0}$		
2-1/2	*	$1.1x10^{0}$	$7.9x10^{0}$	$1.7x10^{1}$	5,000	$6.4x10^{2}$	$1.2x10^{3}$	$5.8x10^{2}$	$1.3x10^{1}$	$2.7x10^{1}$	$2.7x10^{2}$	$4.2x10^{-2}$	$6.1x10^{2}$
Scale from bottom of inlet chute 107-KE	$9.4x10^{-1}$	$1.2x10^{1}$	$4.8x10^{0}$	$1.1x10^{2}$		$5.0x10^{4}$	$7.7x10^{3}$	$1.7x10^{4}$	$1.8x10^{2}$	$7.9x10^{3}$		$1.6x10^{0}$	

Table 3-3. Radionuclide Concentrations in Soil Samples Inside the 107-K Retention Basins (Dorian and Richards 1978). (sheet 2 of 2)

Sample number/ depth (ft)	^{238}Pu	$^{239/240}Pu$	^{90}Sr	^{3}H	P-11/⁺ Scaler cpm	^{52}Eu	^{60}Co	^{154}Eu	^{134}Cs	^{137}Cs	^{155}Eu	U	^{63}Ni
107-KW Basins Concentration (pCi/g)													
AA 1-1/2	*	*	$1.6x10^{-2}$	$5.7x10^{0}$	200	$1.1x10^{1}$	$2.3x10^{1}$	$6.1x10^{0}$	$1.3x10^{-1}$	$3.0x10^{-1}$	$2.1x10^{0}$		
2	*	$2.1x10^{-1}$	$2.9x10^{-1}$	$5.5x10^{-1}$	5,000	$5.6x10^{2}$	$1.3x10^{3}$	$3.4x10^{2}$	$8.2x10^{0}$	$8.8x10^{0}$	$5.0x10^{1}$	$8.8x10^{2}$	
AB 1			*		<200/40	$2.7x10^{0}$	$1.8x10^{0}$	$1.4x10^{0}$	$4.6x10^{-2}$	$7.0x10^{-2}$	$5.4x10^{-1}$		
2	*	$4.3x10^{-1}$	$1.6x10^{-1}$	$1.5x10^{0}$	1,000	$2.1x10^{2}$	$1.9x10^{2}$	$3.9x10^{1}$	*	$9.7x10^{-1}$	$3.5x10^{2}$		
BA 1-1/2	*	*	$9.2x10^{-1}$		<200/60	$5.4x10^{0}$	$1.4x10^{1}$	$7.2x10^{-1}$	*	$1.9x10^{-1}$	$4.0x10^{-1}$		
2	*	$8.3x10^{0}$	$7.9x10^{1}$	$1.7x10^{0}$	3,000	$6.7x10^{2}$	$5.3x10^{2}$	$2.0x10^{2}$	*	$3.0x10^{1}$	$1.6x10^{1}$		
BB 1-1/2			*		<200/40	$1.5x10^{0}$	$1.1x10^{0}$	$5.5x10^{-1}$	*	$1.5x10^{-1}$	*		
2	*	$1.2x10^{0}$	$3.3x10^{0}$	$1.3x10^{0}$	3,000	$5.3x10^{2}$	$9.0x10^{2}$	$3.1x10^{2}$	*	$4.1x10^{0}$	$2.8x10^{1}$		
CA 1-1/2	*	$6.7x10^{-1}$	$1.2x10^{0}$	$6.0x10^{-1}$	600	$1.3x10^{2}$	$9.9x10^{1}$	$1.3x10^{2}$	*	$7.3x10^{-1}$	*		
CB 2	*	$1.1x10^{0}$	$1.2x10^{1}$			$1.1x10^{3}$	$1.0x10^{3}$	$6.6x10^{2}$	$5.3x10^{0}$	$1.8x10^{1}$	$3.6x10^{2}$		

* Less than analytical detection limits.
Blank denotes that data are not available.
⁺ P-11 = a beta/gamma pancake probe for field measurements
scaler = bench-top laboratory count rate meter with a shielded probe for increased sensitivity.
cpm = instrumental measurement in counts per minute.

Table 3-4. Radionuclide Concentrations Inside and Adjacent to the 116-K-1 Effluent Crib.

Sample number/ depth (ft)	^{238}Pu	$^{239/240}Pu$	^{90}Sr	^{3}H	P-11/+ Scaler cpm	^{152}Eu	^{60}Co	^{154}Eu	^{134}Cs	^{137}Cs	^{155}Eu	U
116-K-1 100-K Crib Concentration <u>(pCi/g)</u>												
A' 0			*		<200/5	*	*	*	*	*	*	
5			9.1×10^{-2}		<200/20	*	1.5×10^{-1}	*	*	1.7×10^{-1}	*	2.2×10^{-1}
15			5.6×10^{-1}		<200/Bkg	9.7x10-1	6.4×10^{-1}	6.4×10^{-1}	4.5×10^{-2}	*	*	
B' 5			3.7×10^{-2}		<200/30	*	5.8×10^{-2}	*	*	3.9×10^{-2}	*	
15			2.5×10^{-2}		<200/10	*	*	*	*	*	*	
25	*	3.2×10^{-3}	*		<200/30	*	5.4×10^{-2}	*	*	4.5×10^{-2}	*	1.4×10^{-1}
C' 0	*	*	1.3×10^{-1}		<200/25	4.3x10-1	9.1×10^{-1}	2.4×10^{-1}	*	6.5×10^{-1}	1.6×10^{-1}	1.1×10^{-1}
15			2.9×10^{-2}		<200/20	*	*	*	*	4.6×10^{-2}	1.7×10^{-1}	
25			2.6×10^{-2}		<200/5	*	*	*	3.3×10^{-2}	5.2×10^{-2}	*	
D' 0	4.8x10-1	4.4×10^{0}	1.0×10^{1}		2,500	4.2×10^{2}	3.1×10^{2}	1.7×10^{2}	6.4×10^{0}	7.7×10^{2}	1.4×10^{1}	
5			6.3×10^{0}		1,000	1.3×10^{2}	1.5×10^{2}	5.2×10^{1}	4.0×10^{0}	4.4×10^{2}	4.4×10^{0}	
10			7.2×10^{0}		<200/90	3.0×10^{-1}	3.6×10^{-1}	*	*	6.6×10^{-1}	1.5×10^{-1}	
16			7.9×10^{0}		<200/30	*	*	*	*	*	1.8×10^{-1}	
E' 0	*	2.5×10^{-1}	2.8×10^{0}		300	3.7×10^{1}	3.0×10^{1}	1.3×10^{1}	2.3×10^{-1}	3.4×10^{1}	5.7×10^{-1}	
2-1/2	*	1.8×10^{-1}	5.9×10^{0}		<200/40	1.1×10^{0}	9.7×10^{-1}	4.1×10^{-1}	*	5.9×10^{-1}	*	
24	*	*	1.0×10^{0}		<200/Bkg	*	*	*	*	3.8×10^{-2}	*	

Total Curies inside the crib (average of samples D and E) = 46; total curies outside the crib (average of samples A', B' and C') = 4.3×10^{-1}.

* Less than analytical detection limits.
Blank denotes that data are not available.

\+ P-11 = a beta/gamma pancake probe for field measurements.
scaler = bench top laboratory count rate meter with a shielded probe for increased sensitivity.
cpm = instrumental measurement in counts per minute.

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Table 3-5. Radionuclide Concentrations in Soil Samples Along the 116-K-2 Trench. (sheet 1 of 2)

Sample number /depth (ft)	^{238}Pu	$^{239/240}Pu$	^{90}Sr	^{3}H	P-11/+ Scaler cpm	^{152}Eu	^{60}Co	^{154}Eu	^{134}Cs	^{137}Cs	^{155}Eu	U	^{63}Ni
A 5	3.1×10^{-1}	7.6×10^{0}	2.5×10^{1}		1,500	*	*	*	*				
2A 5	*	*			<200/30	9.7×10^{-1}	2.4×10^{-1}	2.5×10^{-1}	*	1.1×10^{-1}		*	
15	2.4×10^{-1}	2.1×10^{0}	1.8×10^{1}	1.5×10^{1}	1,000	5.8×10^{2}	1.8×10^{2}	1.7×10^{2}	1.3×10^{0}	1.1×10^{2}		9.3×10^{0}	2.5×10^{-1}
20	*	3.0×10^{-1}	5.7×10^{0}		<200/100	4.9×10^{0}	8.6×10^{-1}	9.3×10^{-1}	*	2.6×10^{1}		5.2×10^{-1}	
B 0	1.9×10^{-1}	2.5×10^{0}	6.2×10^{0}	2.7×10^{2}	1,500	6.0×10^{2}	2.7×10^{2}	2.5×10^{2}	5.6×10^{0}	1.2×10^{2}		6.5×10^{1}	3.1×10^{-1}
5	*	*	1.6×10^{0}		<200/15	2.2×10^{-1}	1.0×10^{-1}	*	*	*		*	
10	*	*	2.7×10^{-1}		<200/25	3.4×10^{0}	1.5×10^{0}	1.1×10^{0}	*	5.9×10^{-1}		1.4×10^{-1}	2.4×10^{-1}
C 15	4.0×10^{0}	1.3×10^{2}	2.3×10^{2}	1.4×10^{1}	12,000	4.4×10^{4}	1.3×10^{3}	1.7×10^{4}	5.3×10^{2}	4.8×10^{2}	5.1×10^{3}	9.5×10^{2}	2.1×10^{0}
17-1/2	2.8×10^{-1}	1.1×10^{1}	4.4×10^{1}		2,000	5.8×10^{2}	3.1×10^{2}	1.4×10^{2}	2.8×10^{0}	4.5×10^{2}		3.7×10^{0}	
20	*	1.6×10^{0}	1.4×10^{1}		400	1.6×10^{2}	9.9×10^{1}	6.1×10^{1}	9.7×10^{-1}	5.7×10^{1}		1.3×10^{1}	
25	3.0×10^{-1}	4.9×10^{0}	3.7×10^{1}		2,500	1.2×10^{3}	2.7×10^{2}	4.5×10^{2}	2.3×10^{0}	2.3×10^{2}		5.7×10^{1}	
28	*	5.4×10^{-1}	1.4×10^{1}		600	1.4×10^{2}	5.0×10^{1}	4.7×10^{1}	5.5×10^{-1}	6.5×10^{1}		2.1×10^{1}	
D 5	1.4×10^{-2}	1.2×10^{-1}	6.8×10^{-1}		<200/10	6.6×10^{0}	4.6×10^{0}	2.8×10^{0}	6.7×10^{-2}	2.8×10^{0}		3.8×10^{-1}	
15	4.3×10^{-1}	1.3×10^{1}	5.7×10^{1}	2.7×10^{1}	2,000	1.6×10^{3}	7.3×10^{2}	6.6×10^{2}	2.1×10^{1}	3.9×10^{2}		1.8×10^{2}	4.1×10^{-1}
20	*	8.1×10^{0}	1.1×10^{1}		300	1.5×10^{1}	4.1×10^{0}	7.7×10^{-1}	8.6×10^{-2}	7.2×10^{0}		9.3×10^{-1}	
28	*	*	6.3×10^{0}		<200/10	9.0×10^{-1}	3.3×10^{-1}	*	*	2.5×10^{-1}		*	
E 0	*	*	4.8×10^{-1}		<200/40	2.9×10^{0}	2.2×10^{2}	1.5×10^{0}	*	1.2×10^{0}		2.8×10^{-1}	
12	1.2×10^{0}	2.1×10^{1}	3.0×10^{1}	8.1×10^{1}	5,000	2.2×10^{3}	7.4×10^{2}	7.4×10^{2}	2.8×10^{1}	9.2×10^{2}		2.3×10^{2}	5.5×10^{-1}
16	3.0×10^{-1}	4.0×10^{0}	6.7×10^{0}		900	3.5×10^{2}	1.1×10^{2}	1.2×10^{2}	1.1×10^{0}	1.9×10^{2}		4.0×10^{0}	
20	*	3.7×10^{-1}	4.4×10^{0}		250	2.9×10^{1}	3.8×10^{1}	1.1×10^{1}	6.5×10^{-1}	6.9×10^{1}		*	
25	*	2.6×10^{-1}	6.2×10^{0}		<200/50	6.9×10^{0}	4.6×10^{0}	2.0×10^{0}	1.3×10^{-1}	1.3×10^{1}		9.6×10^{-1}	
F 0	*	2.0×10^{-1}	2.3×10^{-1}		<200/80	4.7×10^{0}	2.5×10^{0}	*	*	1.6×10^{0}		*	

Table 3-5. Radionuclide Concentrations in Soil Samples Along the 116-K-2 Trench. (sheet 2 of 2)

Sample number /depth (ft)	^{238}Pu	$^{239/240}Pu$	^{90}Sr	^{3}H	P-11/+ Scaler cpm	^{152}Eu	^{60}Co	^{154}Eu	^{134}Cs	^{137}Cs	^{155}Eu	U	^{63}Ni
12	*	2.0×10^{0}	4.7×10^{0}	2.2×10^{0}	00	2.8×10^{2}	1.8×10^{2}	8.2×10^{1}	9.0×10^{-1}	3.4×10^{2}		5.6×10^{0}	2.6×10^{-1}
20	*	6.1×10^{-1}	7.4×10^{0}		<200/100	5.8×10^{1}	4.1×10^{1}	1.8×10^{1}	5.3×10^{-1}	1.7×10^{2}		8.2×10^{-1}	
G 0	1.6×10^{-2}	*	7.6×10^{-2}		<200/55	*	1.5×10^{-1}	*	6.2×10^{-2}	6.4×10^{-1}		2.7×10^{-1}	
3G 19	3.7×10^{-1}	7.1×10^{0}	1.5×10^{1}	5.5×10^{1}	1,500	1.1×10^{3}	5.0×10^{2}	3.4×10^{2}	3.4×10^{0}	7.1×10^{2}		2.6×10^{1}	5.8×10^{-1}
15	*	4.2×10^{0}	7.6×10^{0}		500	8.7×10^{1}	4.8×10^{1}	2.9×10^{1}	2.9×10^{-1}	9.3×10^{1}		1.1×10^{0}	
18	*	9.4×10^{-1}	1.6×10^{0}		400	1.2×10^{2}	1.2×10^{2}	3.9×10^{1}	1.6×10^{0}	1.2×10^{2}		6.3×10^{0}	
21	*	*	1.9×10^{0}		<200/15	5.8×10^{-1}	7.8×10^{-1}	4.4×10^{-1}	*	8.2×10^{0}		3.1×10^{-1}	
I 15	*	*	3.5×10^{-2}		<200/20	2.7×10^{-1}	9.0×10^{-2}	*	*	1.5×10^{-1}		8.8×10^{-2}	
17	8.7×10^{-1}	2.0×10^{1}	3.3×10^{1}	1.3×10^{2}	3,000	3.0×10^{3}	8.4×10^{2}	9.9×10^{2}	1.1×10^{1}	9.5×10^{2}		3.8×10^{1}	1.2×10^{-1}
19	*	*	3.0×10^{0}		500	2.9×10^{1}	2.1×10^{2}	1.1×10^{1}	*	*		3.6×10^{-1}	
23	*	*	3.4×10^{0}		<200/20	3.3×10^{0}	2.0×10^{0}	1.4×10^{0}	4.2×10^{-2}	1.7×10^{0}		3.1×10^{-1}	
K 0	*	*	3.5×10^{-2}		<200/40	*	*	*	*	7.1×10^{-2}		2.0×10^{-1}	
22	6.4×10^{-1}	1.3×10^{1}	1.9×10^{1}	9.1×10^{1}	3,000	3.8×10^{3}	2.2×10^{3}	1.4×10^{3}	1.5×10^{1}	3.0×10^{3}		1.4×10^{4}	4.5×10^{-1}
27	9.0×10^{-2}	1.4×10^{0}	2.6×10^{0}		1,000	2.2×10^{2}	1.7×10^{2}	8.3×10^{1}	1.0×10^{0}	1.0×10^{2}		1.1×10^{1}	
30	*	1.9×10^{-1}	2.0×10^{0}		<200	6.1×10^{0}	4.4×10^{1}	*	*	2.6×10^{0}		*	
L 0	*	*	2.1×10^{-1}		<200/30	*	*	3.1×10^{-1}	4.9×10^{-2}	*		1.2×10^{-1}	
17	*	1.1×10^{0}	3.5×10^{0}	2.2×10^{1}	<200/130	2.3×10^{1}	1.1×10^{2}	1.2×10^{1}	1.7×10^{-1}	2.4×10^{1}		3.7×10^{0}	4.2×10^{-1}
M 0	*	3.6×10^{-1}	5.5×10^{-2}		<200/40	*	1.4×10^{-1}	5.6×10^{-1}	*	1.3×10^{-1}		*	
17	*	*	1.3×10^{0}	2.8×10^{0}	<200/150	4.0×10^{-1}	1.1×10^{-1}	*	4.7×10^{-2}	5.7×10^{-2}		1.8×10^{-1}	1.9×10^{-1}
20	*	6.3×10^{-1}	9.3×10^{-1}		<200/25	3.7×10^{-1}	9.3×10^{-2}	4.4×10^{-1}	*	2.9×10^{-2}		*	

Total Curies = 2,100.
* Less than analytical detection limits.
Blank denotes that data are not available.
\+ P-11 = a beta/gamma pancake probe for field measurements.
scaler = bench top laboratory count rate meter with a shielded probe for increased sensitivity.
cpm = instrumental measurement in counts per minute.

Table 3-6. Radionuclide Concentrations in Soils Outside the 107-K Retention Basins (Dorian and Richards 1978). (sheet 1 of 3)

Sample number/ depth (ft)	^{238}Pu	$^{239/240}$Pu	^{90}Sr	^{3}H	P-11/$^{+}$ Scaler cpm	^{152}Eu	^{60}Co	^{154}Eu	^{134}Cs	^{137}Cs	^{155}Eu
107-KE Basin											
C 0	*	*	3.9×10^{-1}		<200/70	1.2×10^{1}	5.5×10^{0}	5.2×10^{0}	*	5.2×10^{-1}	4.7×10^{-1}
D 0	*	*	1.2×10^{0}		<200/80	1.4×10^{1}	8.8×10^{0}	5.2×10^{0}	*	2.4×10^{1}	1.3×10^{0}
E 5	*	*	3.0×10^{-1}		<200/50	2.3×10^{1}	1.2×10^{1}	7.8×10^{0}	2.0×10^{-1}	1.3×10^{0}	2.7×10^{0}
F 0	*	*	8.8×10^{-1}		<200/40	9.4×10^{0}	7.9×10^{0}	4.3×10^{0}	*	3.9×10^{0}	6.0×10^{-1}
5	*	*	4.5×10^{-1}		<200/30	3.5×10^{0}	3.3×10^{0}	1.3×10^{0}	*	2.3×10^{0}	1.4×10^{-1}
G 15			1.2×10^{-1}		<200/25	3.6×10^{-1}	1.4×10^{-1}	*	*	3.7×10^{-2}	2.0×10^{-1}
H 0	*	*	4.4×10^{-1}	*	<200/50	2.5×10^{1}	8.4×10^{0}	8.3×10^{0}	*	1.4×10^{0}	2.1×10^{0}
5			4.3×10^{-1}		<200/25	1.9×10^{0}	8.6×10^{-1}	8.1×10^{-1}	*	4.1×10^{-1}	2.7×10^{-1}
I 0	*	*	2.8×10^{-1}	5.3×10^{-1}	<200/25	5.5×10^{0}	6.5×10^{-1}	2.0×10^{0}	8.2×10^{-2}	1.9×10^{-1}	4.6×10^{-1}
J 0	*	*	1.6×10^{0}	1.3×10^{0}	<200/100	2.9×10^{1}	1.7×10^{1}	1.2×10^{1}	*	3.6×10^{0}	6.8×10^{-1}
15			1.8×10^{-1}		<200/15	$1.1\times10^{-}$	1.0×10^{-1}	*	*	3.4×10^{-2}	1.1×10^{-1}
K 0			7.4×10^{-1}		<200/25	5.9×10^{0}	2.7×10^{0}	2.4×10^{0}	6.9×10^{-2}	7.4×10^{-1}	1.5×10^{0}
L 0	*	*	3.2×10^{-1}	*	<200/30	2.2×10^{0}	3.7×10^{-1}	9.6×10^{-1}	6.8×10^{-2}	3.4×10^{-1}	2.8×10^{-1}
M 1	*	*	4.3×10^{-1}		400	2.8×10^{1}	3.3×10^{1}	1.1×10^{1}	*	9.2×10^{0}	1.1×10^{1}
0			2.3×10^{0}	*	400	6.2×10^{1}	4.1×10^{1}	2.5×10^{1}		4.0×10^{1}	1.3×10^{0}
20	*	*	1.1×10^{0}		<200/50	1.3×10^{0}	6.6×10^{-1}	1.1×10^{0}	5.2×10^{-2}	2.3×10^{1}	7.5×10^{-1}
	*	2.1×10^{-1}							1.0×10^{-1}		
	*	*									
N 0	*	1.2×10^{-1}	1.9×10^{0}	*	<200/60	3.8×10^{1}	1.3×10^{1}	1.3×10^{1}	*	1.2×10^{1}	2.2×10^{0}

Table 3-6. Radionuclide Concentrations in Soils Outside the 107-K Retention Basins (Dorian and Richards 1978). (sheet 2 of 3)

Sample number/ depth (ft)	^{238}Pu	$^{239/240}Pu$	^{90}Sr	^{3}H	P-11 Scaler+ cpm	^{152}Eu	^{60}Co	^{154}Eu	^{134}Cs	^{137}Cs	^{155}Eu
107-KW Basin:											
B 0	*	*	6.9×10^{-1}	4.9×10^{-1}	<200/50	2.0×10^{1}	1.1×10^{1}	1.0×10^{1}	5.0×10^{-1}	2.0×10^{0}	4.3×10^{0}
25	*	*	2.6×10^{-1}		<200/25	*	*	*	*	4.3×10^{-2}	*
C 0			2.1×10^{-1}	*	<200/50	1.5×10^{1}	2.4×10^{0}	4.3×10^{0}	*	5.3×10^{-1}	9.6×10^{-1}
20	*	*	*		<200/30	*	*	*	*	*	*
D 0			6.9×10^{-1}	*	<200/80	2.2×10^{1}	1.2×10^{1}	1.1×10^{1}	2.1×10^{-1}	3.8×10^{0}	4.5×10^{0}
10	*	*	1.8×10^{-1}		<200/25	2.2×10^{0}	1.0×10^{0}	5.1×10^{-1}	4.1×10^{-2}	7.6×10^{-1}	2.8×10^{-1}
E 0			1.4×10^{-1}	4.3×10^{-1}	<200/40	6.8×10^{0}	3.6×10^{0}	3.2×10^{0}	5.9×10^{-2}	2.0×10^{0}	1.3×10^{0}
20			*		<200/20	4.8×10^{-1}	4.1×10^{-2}	*	*	*	*
	*	3.5×10^{-1}									
F 0	*	*	3.0×10^{-2}		<200/40	3.5×10^{0}	2.6×10^{0}	4.3×10^{0}	5.9×10^{-2}	3.7×10^{-1}	1.5×10^{0}
15			*		<200/15	*	3.7×10^{-2}	*	*	*	1.7×10^{-1}
G 0			4.0×10^{-1}	*	<200/50	1.1×10^{1}	6.0×10^{0}	4.9×10^{0}	*	1.1×10^{0}	1.8×10^{0}
8	*	*	5.4×10^{-2}		<200/30	1.1×10^{0}	4.8×10^{-1}	7.0×10^{-1}	*	1.6×10^{-1}	2.9×10^{-1}
H 0			9.8×10^{-1}	*	<200/50	6.3×10^{0}	1.1×10^{1}	1.3×10^{1}	1.5×10^{-1}	2.8×10^{0}	6.9×10^{0}
	*	*									

Table 3-6. Radionuclide Concentrations in Soils Outside the 107-K Retention Basins (Dorian and Richards 1978). (sheet 3 of 3)

Sample number/ depth (ft)	^{238}Pu	$^{239/240}Pu$	^{90}Sr	^{3}H	P-11 Scaler+ cpm	^{152}Eu	^{60}Co	^{154}Eu	^{134}Cs	^{137}Cs	^{155}Eu
20			3.9×10^{-2}		<200/25	*	4.4×10^{-2}	*	4.3×10^{-2}	•	1.0×10^{-1}
I 0	*	*	1.3×10^{-1}		<200/25	3.4×10^{0}	1.2×10^{0}	1.3×10^{0}	*	7.3×10^{-1}	2.8×10^{-1}
J 0		1.4×10^{-1}	1.5×10^{0}	*	<200/60	2.1×10^{1}	8.9×10^{0}	6.4×10^{0}	*	3.1×10^{0}	2.7×10^{-1}
K 01	*	*	1.8×10^{0}		5,000	8.1×10^{2}	1.0×10^{1}	1.8×10^{2}	1.9×10^{0}	6.9×10^{0}	5.7×10^{2}
0	*	1.0×10^{-1}	1.9×10^{0}	*	<200/50	1.6×10^{1}	7.6×10^{0}	7.1×10^{0}	2.5×10^{-1}	5.3×10^{0}	2.3×10^{0}
L 01	*	5.2×10^{-1}	7.8×10^{0}	4.3×10^{-1}	600	1.3×10^{2}	5.0×10^{1}	3.3×10^{1}	*	2.8×10^{1}	2.6×10^{2}
0		2.3×10^{-1}	2.7×10^{0}	1.1×10^{0}	<200/140	5.4×10^{1}	2.2×10^{1}	1.8×10^{1}	*	1.5×10^{1}	1.2×10^{0}
M 0	*	3.2×10^{0}	3.8×10^{1}	7.8×10^{0}	800	5.6×10^{2}	2.6×10^{2}	2.4×10^{2}	3.9×10^{0}	2.4×10^{2}	2.4×10^{1}
N 0	*		1.1×10^{0}		<200/15	1.3×10^{0}	3.6×10^{-1}	3.0×10^{-1}	*	2.6×10^{0}	1.2×10^{-1}
15	*	*	1.1×10^{0}	3.2×10^{1}	<200/25	9.4×10^{-1}	2.1×10^{-1}	2.1×10^{-1}	*	4.3×10^{0}	1.7×10^{-1}
	*										

* Less than analytical detection limits.
Blank denotes that data are not available.
Data for test holes A and B for the 107-KE Basin and A and O for the 107-KW Basin not reported.
+ P-11 = a beta/gamma pancake probe for field measurements.
scaler = bench top laboratory count rate meter with a shielded probe for increased sensitivity.
cpm = instrumental measurement in counts per minute.

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Table 3-7. Radionuclide Concentrations in Water from 105-KE Fuel Storage Basin in 1978 (Dorian and Richards 1978).

Radionuclide	Concentration (pCi/L)
^{3}H	6.2 E + 05
^{60}Co	1.2 E + 05
^{90}Sr	3.8 E + 07
^{137}Cs	2.2 E + 07
^{238}Pu	3.0 E + 03
$^{239/240}Pu$	1.7 E + 04

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Table 3-8. Radionuclide Inventory in Soil Near the 105-KE Fuel Storage Basin in 1978 (Dorian and Richards 1978).

Radionuclide	Inventory (Ci)
^{60}Co	3.6 E + 00
^{90}Sr	1.5 E + 00
^{137}Cs	1.5 E + 03
^{238}Pu	2.1 E - 01
$^{239/240}Pu$	1.3 E + 00

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Table 3-9. Estimated Radionuclide Inventory in 105-KE Reactor March 1, 1985 (Ci)[a] (DOE 1989).

Radio-nuclides	Graphite Stack	Thermal Shield	Process Tubes	Control System	Bioshield	Storage Basin	Total
^{3}H	30,000	--	--	--	--	--	30,000
^{14}C	7,000	--	--	--	--	--	7,000
^{41}Ca	1	--	--	--	15	--	16
^{60}Co	5	17,500	190	110	--	0.23	17,805.23
^{59}NI	--	9	13	--	--	0.01	22.01
^{63}NI	11	1,200	1,700	--	--	1.25	2,912.25
^{36}Cl	54	--	--	--	--	--	54
^{90}Sr	10	--	0.3	--	--	0.29	10.59
^{93}Zr	--	--	11	--	--	--	11
^{93}Mo	--	0.06	0.2	--	--	--	0.26
^{94}Nb	1.1	0.03	0.6	--	--	--	0.73
^{99}Tc	--	0.003	0.03	--	--	--	0.033
^{108}AG	--	0.04	--	--	--	--	0.04
^{137}Cs	30	--	--	--	--	0.81	30.81
^{152}Eu	40	--	2	--	--	0.23	42.23
^{154}Eu	20	--	1.6	--	--	0.05	21.65
^{238}U	--	--	--	--	--	--	--
^{238}Pu	--	--	--	--	--	--	--
^{239}Pu	1	--	--	--	--	0.024	1.024
^{241}Am	0.3	--	--	--	--	0.008	0.308

[a]Based on Miller and Steffes 1987 (Table 22).

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Table 3-10. Estimated Radionuclide Inventory in 105-KE Reactor March 1, 1985 (Ci)[a] (DOE 1989).

Radio-nuclides	Graphite Stack	Thermal Shield	Process Tubes	Control System	Bioshield	Storage Basin	Total
^{3}H	27,000	--	--	--	--	--	27,000
^{14}C	6,700	--	--	--	--	--	6,7000
^{41}Ca	5	--	--	--	15	--	20
^{60}Co	5	14,500	170	110	--	0.23	14,785.23
^{59}NI	--	9	11	--	--	0.01	20.01
^{63}NI	15	1,100	1,500	--	--	1.25	2,616.25
^{36}Cl	52	--	--	--	--	--	52
^{90}Sr	10	--	0.3	--	--	0.29	10.59
^{93}Zr	--	--	10	--	--	--	10
^{93}Mo	--	0.06	0.2	--	--	--	0.26
^{94}Nb	1.1	0.03	0.6	--	--	--	1.73
^{99}Tc	--	0.003	0.03	--	--	--	0.033
^{108}AG	--	0.04	--	--	--	--	0.04
^{137}Cs	30	--	--	--	--	0.81	30.81
^{152}Eu	40	--	2	--	--	0.23	42.23
^{154}Eu	20	--	1.6	--	--	0.05	21.65
^{238}U	--	--	--	--	--	--	--
^{238}Pu	--	--	--	--	--	--	--
^{239}Pu	1	--	--	--	--	0.024	1.024
^{241}Am	0.3	--	--	--	--	0.008	0.308

[a]Based on Miller and Steffes 1987 (Table 22).

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Table 3-11. Radionuclide Concentrations in Sediments from the 105-KW Fuel Storage Basin (Dorian and Richards 1978).

		Concentration (pCi/g)										
Area	Location	^{238}Pu	$^{239/240}Pu$	^{90}Sr	^{3}H	^{155}Eu	^{137}Cs	^{154}Eu	^{60}Co	^{152}Eu	U	^{63}Ni
105-KW	Dummy ele. pit	4.2×10^{1}	1.3×10^{3}	9.8×10^{3}	4.7×10^{1}	2.5×10^{4}	1.7×10^{4}	9.3×10^{4}	6.0×10^{5}	1.5×10^{4}	3.8×10^{1}	
105-KW	Pickup chutes	8.7×10^{1}	1.4×10^{3}	1.8×10^{3}	3.2×10^{2}	3.4×10^{4}	4.1×10^{4}	6.2×10^{4}	3.7×10^{5}	1.2×10^{4}	7.3×10^{1}	
105-KW	Transfer area	7.6×10^{1}	4.7×10^{2}	2.0×10^{3}	6.4×10^{1}	1.1×10^{4}	3.5×10^{4}	2.5×10^{4}	1.1×10^{5}	1.9×10^{4}	6.5×10^{1}	
105-KW	Center basin	2.2×10^{2}	3.2×10^{3}	5.2×10^{3}	1.0×10^{2}	1.6×10^{5}	5.1×10^{4}	6.9×10^{5}	1.9×10^{6}	7.3×10^{5}	4.5×10^{1}	6.5×10^{5}
Average		1.1×10^{2}	1.6×10^{3}	4.7×10^{3}	1.3×10^{2}	5.8×10^{4}	3.6×10^{4}	2.2×10^{5}	7.4×10^{5}	1.9×10^{5}	5.5×10^{1}	

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Table 3-12. Radionuclide Concentrations for the 105-KE Fuel Storage Basin.

Sample I.D.	Beta Total	Alpha Total	$^{239/40}Pu$	^{238}Pu	U g/g	^{241}Am	^{144}Ce	^{60}Co	^{134}Cs	^{137}Cs	^{154}Eu	^{155}Eu	^{54}Mn	^{95}Nb	^{106}Rh	^{125}Sb	^{226}Ra	^{95}Zr
2253	4576.0	114.2	79.6	9.2	0.268	16.99		1.29	0.69	145.61	12.25	14.75			3.94	11.14		
Sand filter 3	1317.0	86.6	53.4	8.0	0.141	19.95	51.17	19.85	1.23	90.29	12.20	11.78	2.90		31.74	4.21		
Seg pit #1	2726.0	216.9	128.	18.8	0.352	47.73	30.49	23.34	0.73	66.14	26.03	25.09	2.01		36.00	10.39		
2226	141.6	7.62	5.19	1.04	0.013	1.86		2.11	0.17	14.45	1.12	0.97	0.12		1.47			
5817	907.2	33.5	9.79	1.58	0.031	3.64	23.97	8.54	0.42	28.48	2.45	2.54	0.62	0.19	12.02	0.98		
0851	1848.0	122.1	34.8	5.76	0.114	15.22	15.89	13.89	0.63	5.28	9.41	8.77	0.91	0.09	11.87	2.13		
3153	1079.0	73.2	43.6	7.19	0.133	18.46	22.63	22.34	0.78	49.22	11.46	10.73	0.66		17.81	2.69		
Seg pit #2	2961.0	69.24	37.77	5.14	0.018	13.96		18.79	3.34	234.46	8.04	7.33	0.19		7.41	3.31	2.92	
0812	651.4	45.79	26.6	4.05	0.086	11.28	10.72	15.94	0.48	31.37	6.63	6.20	0.77		14.42	2.54		
5851	491.5	21.0	11.2	1.26	0.033	4.63	12.35	8.22	0.69	61.77	3.05	3.04	0.42		6.94			
3121	874.6	103.8	54.7	6.78	0.163	20.43		19.81	1.30	106.34	10.02	4.90	0.63		15.64	4.66		
South load out	801.4	48.2	23.3	3.16	0.105	9.72	28.54		0.54	40.72		5.94	2.90	2.08	16.64	5.71		
Gamma pit	476.5	4.4	2.35	0.45	0.014	0.72		1.07	0.16	21.93		0.03[1]						
Sand filter #1	1228.0	75.1	44.1	8.33	0.116	15.90	46.26	16.11	0.80	53.96	10.21	9.18	2.87	1.15	28.95	4.32		1.4
Sand filter #2	1363.0	84.6	51.9	9.13	0.136	18.74	57.49	17.34	0.92	59.79	11.92	11.35	3.47	1.20	34.08	4.57		1.6

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Table 3-13. Data From Onsite and Offsite Background Soil Sampling, Hanford Environmental Monitoring Program 1988 (From Jaquish and Bryce 1989).

Radionuclide	Onsite Maximum pCi/g (dry weight)	Offsite Maximum pCi/g (dry weight)
Strontium-90	0.77 ± 0.02	0.43 ± 0.02
Cesium-137	26.0 ± 0.1	1.80 ± 0.1
Plutonium-239/240	0.67 ± 0.12	0.33 ± 0.002
Uranium	1.2 ± 0.3	1.1 ± 0.4

Note: This is 1988 data.

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Table 3-14. Radionuclide Concentrations in Soils Outside the 107-K Retention Basins (Dorian and Richards 1978). (sheet 1 of 3)

Sample number/ depth (ft)	^{238}Pu	$^{239/240}Pu$	^{90}Sr	^{3}H	P-11/+ Scaler cpm	^{152}Eu	^{60}Co	^{154}Eu	^{134}Cs	^{137}Cs	^{155}Eu
107-KE Basin											
C 0	*	*	3.9×10^{-1}		<200/70	1.2×10^{1}	5.5×10^{0}	5.2×10^{0}	*	5.2×10^{-1}	4.7×10^{-1}
D 0	*	*	1.2×10^{0}		<200/80	1.4×10^{1}	8.8×10^{0}	5.2×10^{0}	*	2.4×10^{1}	1.3×10^{0}
E 5	*	*	3.0×10^{-1}		<200/50	2.3×10^{1}	1.2×10^{1}	7.8×10^{0}	2.0×10^{-1}	1.3×10^{0}	2.7×10^{0}
F 0	*	*	8.8×10^{-1}		<200/40	9.4×10^{0}	7.9×10^{0}	4.3×10^{0}	*	3.9×10^{0}	6.0×10^{-1}
5	*	*	4.5×10^{-1}		<200/30	3.5×10^{0}	3.3×10^{0}	1.3×10^{0}	*	2.3×10^{0}	1.4×10^{-1}
G 15			1.2×10^{-1}		<200/25	3.6×10^{-1}	1.4×10^{-1}	*	*	3.7×10^{-2}	2.0×10^{-1}
H 0	*	*	4.4×10^{-1}	*	<200/50	2.5×10^{1}	8.4×10^{0}	8.3×10^{0}	*	1.4×10^{0}	2.1×10^{0}
5			4.3×10^{-1}		<200/25	1.9×10^{0}	8.6×10^{-1}	8.1×10^{-1}	*	4.1×10^{-1}	2.7×10^{-1}
I 0	*	*	2.8×10^{-1}	5.3×10^{-1}	<200/25	5.5×10^{0}	6.5×10^{-1}	2.0×10^{0}	8.2×10^{-2}	1.9×10^{-1}	4.6×10^{-1}
J 0	*	*	1.6×10^{0}	1.3×10^{0}	<200/100	2.9×10^{1}	1.7×10^{1}	1.2×10^{1}	*	3.6×10^{0}	6.8×10^{-1}
15			1.8×10^{-1}		<200/15	$1.1 \times 10^{-}$	1.0×10^{-1}	*	*	3.4×10^{-2}	1.1×10^{-1}
K 0			7.4×10^{-1}		<200/25	5.9×10^{0}	2.7×10^{0}	2.4×10^{0}	6.9×10^{-2}	7.4×10^{-1}	1.5×10^{0}
L 0	*	*	3.2×10^{-1}	*	<200/30	2.2×10^{0}	3.7×10^{-1}	9.6×10^{-1}	6.8×10^{-2}	3.4×10^{-1}	2.8×10^{-1}
M 1	*	*	4.3×10^{-1}		400	2.8×10^{1}	3.3×10^{1}	1.1×10^{1}	*	9.2×10^{0}	1.1×10^{1}
0	*	*	2.3×10^{0}	*	400	6.2×10^{1}	4.1×10^{1}	2.5×10^{1}	5.2×10^{-2}	4.0×10^{1}	1.3×10^{0}
20	*	2.1×10^{-1}	1.1×10^{0}		<200/50	1.3×10^{0}	6.6×10^{-1}	1.1×10^{0}	1.0×10^{-1}	2.3×10^{1}	7.5×10^{-1}
	*	*									
N 0	*	1.2×10^{-1}	1.9×10^{0}	*	<200/60	3.8×10^{1}	1.3×10^{1}	1.3×10^{1}	*	1.2×10^{1}	2.2×10^{0}

Table 3-14. Radionuclide Concentrations in Soils Outside the 107-K Retention Basins (Dorian and Richards 1978). (sheet 2 of 3)

Sample number/ depth (ft)	^{238}Pu	$^{239/240}Pu$	^{90}Sr	^{3}H	P-11 Scaler+ cpm	^{152}Eu	^{60}Co	^{154}Eu	^{134}Cs	^{137}Cs	^{155}Eu
107-KW Basin:											
B 0	*	*	6.9×10^{-1}	4.9×10^{-1}	<200/50	2.0×10^{1}	1.1×10^{1}	1.0×10^{1}	5.0×10^{-1}	2.0×10^{0}	4.3×10^{0}
25	*	*	2.6×10^{-1}		<200/25	*	*	*	*	4.3×10^{-2}	*
C 0			2.1×10^{-1}	*	<200/50	1.5×10^{1}	2.4×10^{0}	4.3×10^{0}	*	5.3×10^{-1}	9.6×10^{-1}
20	*	*	*		<200/30	*	*	*	*	*	*
D 0			6.9×10^{-1}	*	<200/80	2.2×10^{1}	1.2×10^{1}	1.1×10^{1}	2.1×10^{-1}	3.8×10^{0}	4.5×10^{0}
10	*	*	1.8×10^{-1}		<200/25	2.2×10^{0}	1.0×10^{0}	5.1×10^{-1}	4.1×10^{-2}	7.6×10^{-1}	2.8×10^{-1}
E 0			1.4×10^{-1}	4.3×10^{-1}	<200/40	6.8×10^{0}	3.6×10^{0}	3.2×10^{0}	5.9×10^{-2}	2.0×10^{0}	1.3×10^{0}
20			*		<200/20	4.8×10^{-1}	4.1×10^{-2}	*	*	*	*
	*	3.5×10^{-1}									
F 0	*	*	3.0×10^{-2}		<200/40	3.5×10^{0}	2.6×10^{0}	4.3×10^{0}	5.9×10^{-2}	3.7×10^{-1}	1.5×10^{0}
15			*		<200/15	*	3.7×10^{-2}	*	*	*	1.7×10^{-1}
G 0			4.0×10^{-1}	*	<200/50	1.1×10^{1}	6.0×10^{0}	4.9×10^{0}	*	1.1×10^{0}	1.8×10^{0}
8	*	*	5.4×10^{-2}		<200/30	1.1×10^{0}	4.8×10^{-1}	7.0×10^{-1}	*	1.6×10^{-1}	2.9×10^{-1}
H 0			9.8×10^{-1}	*	<200/50	6.3×10^{0}	1.1×10^{1}	1.3×10^{1}	1.5×10^{-1}	2.8×10^{0}	6.9×10^{0}
	*	*									

9 1 1 2 1 9 7 1 4 3 2

Table 3-14. Radionuclide Concentrations in Soils Outside the 107-K Retention Basins (Dorian and Richards 1978). (sheet 3 of 3)

Sample number/ depth (ft)	^{238}Pu	$^{239/240}Pu$	^{90}Sr	^{3}H	P-11 Scaler+ cpm	^{152}Eu	^{60}Co	^{154}Eu	^{134}Cs	^{137}Cs	^{155}Eu
20			3.9×10^{-2}		<200/25	*	4.4×10^{-2}	*	4.3×10^{-2}	*	1.0×10^{-1}
I 0	*	*	1.3×10^{-1}		<200/25	3.4×10^{0}	1.2×10^{0}	1.3×10^{0}	*	7.3×10^{-1}	2.8×10^{-1}
J 0		1.4×10^{-1}	1.5×10^{0}	*	<200/60	2.1×10^{1}	8.9×10^{0}	6.4×10^{0}	*	3.1×10^{0}	2.7×10^{-1}
K 01	*	*	1.8×10^{0}		5,000	8.1×10^{2}	1.0×10^{1}	1.8×10^{2}	1.9×10^{0}	6.9×10^{0}	5.7×10^{2}
0	*	1.0×10^{-1}	1.9×10^{0}	*	<200/50	1.6×10^{1}	7.6×10^{0}	7.1×10^{0}	2.5×10^{-1}	5.3×10^{0}	2.3×10^{0}
L 01	*	5.2×10^{-1}	7.8×10^{0}	4.3×10^{-1}	600	1.3×10^{2}	5.0×10^{1}	3.3×10^{1}	*	2.8×10^{1}	2.6×10^{2}
0		2.3×10^{-1}	2.7×10^{0}	1.1×10^{0}	<200/140	5.4×10^{1}	2.2×10^{1}	1.8×10^{1}	*	1.5×10^{1}	1.2×10^{0}
M 0	*	3.2×10^{0}	3.8×10^{1}	7.8×10^{0}	800	5.6×10^{2}	2.6×10^{2}	2.4×10^{2}	3.9×10^{0}	2.4×10^{2}	2.4×10^{1}
N 0	*		1.1×10^{0}		<200/15	1.3×10^{0}	3.6×10^{-1}	3.0×10^{-1}	*	2.6×10^{0}	1.2×10^{-1}
15	*	*	1.1×10^{0}	3.2×10^{1}	<200/25	9.4×10^{-1}	2.1×10^{-1}	2.1×10^{-1}	*	4.3×10^{0}	1.7×10^{-1}
	*										

* Less than analytical detection limits.
Blank denotes that data are not available.
Data for test holes A and B for the 107-KE Basin and A and O for the 107-KW Basin not reported.
+ P-11 = a beta/gamma pancake probe for field measurements.
scaler = bench top laboratory count rate meter with a shielded probe for increased sensitivity.
cpm = instrumental measurement in counts per minute.

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Table 3-15. Summary of Radionuclide Inventory In and Near 116-K-1 (Crib) and 116-K-2 (Trench) (Dorian and Richards 1978).

Source	Inventory Ci
116-K-1 Crib	46.0
116-K-2 Trench	2,100.0
Adjacent to 116-K-1 Crib	0.43
Adjacent to 116-K-2 Trench	11.7

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Table 3-16. Radionuclide Concentrations in Soils Samples Outside the 116-K-1 Trench. (sheet 1 of 2)

Sample no./ depth (ft)	Concentration (pCi/g)											
	^{238}Pu	$^{239/240}Pu$	^{90}Sr	^{3}H	P-11/+ Scaler cpm	^{152}Eu	^{60}Co	^{154}Eu	^{134}Cs	^{137}Cs	^{155}Eu	U
N 10	*	*	*	5.7×10^{-1}	<200/10	4.0×10^{-1}	8.2×10^{-2}	*	*	7.3×10^{-2}	*	1.9×10^{-1}
O												
P 5	*	*	5.5×10^{-2}	2.9×10^{0}	<200/20	7.9×10^{-1}	2.9×10^{-1}	*	7.5×10^{-2}	1.8×10^{-1}	3.6×10^{-1}	2.6×10^{-1}
15	*	*	2.2×10^{-2}		<200/10	*	*	*	*	4.0×10^{-2}	2.5×10^{-1}	
30	*	*	5.8×10^{-1}		<200/10	*	*	1.9×10^{-1}	*	*	5.8×10^{-2}	
Q 0	*	*	3.1×10^{-1}		<200/25	5.1×10^{0}	1.9×10^{0}	1.9×10^{0}	*	8.8×10^{-1}	3.5×10^{-1}	
20	*	*	*	1.0×10^{0}	<200/10	1.7×10^{-1}	7.8×10^{-2}	*	7.0×10^{-2}	5.6×10^{-2}	*	3.0×10^{-1}
R 5	*	*	2.5×10^{-1}	9.1×10^{-1}	<200/25	5.6×10^{-1}	1.0×10^{-1}	*	4.9×10^{-2}	7.8×10^{-1}	*	3.6×10^{-1}
15	*	*	*		<200/10	2.3×10^{-1}	7.2×10^{-2}	*	*	3.9×10^{-2}	*	
S 0	*	*	4.6×10^{-1}	1.0×10^{0}	<200/25	2.1×10^{-1}	5.1×10^{-2}	*	*	*	2.0×10^{-1}	2.2×10^{-1}
18	*	*	1.6×10^{-1}		<200/10	*	*	*	4.0×10^{-2}	3.6×10^{-2}	1.8×10^{-1}	
T 15	*	1.9×10^{-1}	1.6×10^{-1}	1.7×10^{0}	<200/10	5.7×10^{-1}	*	*	5.3×10^{-2}	*	*	1.6×10^{-1}
U 0	*	*	9.7×10^{-2}	5.5×10^{-1}	<200/20	*	5.1×10^{-2}	*	*	6.9×10^{-2}	*	2.7×10^{-1}
V 0-1	*	*	2.0×10^{0}	2.7×10^{-1}	250	1.6×10^{1}	3.5×10^{0}	5.9×10^{0}	5.1×10^{-2}	2.8×10^{0}	4.9×10^{-1}	1.7×10^{-1}
0-2	*	*	2.2×10^{0}	2.3×10^{0}	600	1.3×10^{2}	6.1×10^{1}	5.3×10^{1}	2.1×10^{0}	9.7×10^{1}	1.5×10^{1}	2.8×10^{-1}
5	*	*	1.9×10^{0}		<200/15	4.7×10^{-1}	1.4×10^{-1}	*	*	3.5×10^{-2}	1.5×10^{-1}	
15	*	*	6.7×10^{-1}		<200/20	3.1×10^{-1}	5.8×10^{-2}	*	*	*	*	
W												

Table 3-16. Radionuclide Concentrations in Soils Samples Outside the 116-K-1 Trench. (sheet 2 of 2)

Concentration (pCi/g)

Sample no./ depth (ft)	^{238}Pu	$^{239/240}$Pu	^{90}Sr	^{3}H	P-11/+ Scaler cpm	^{152}Eu	^{60}Co	^{154}Eu	^{134}Cs	^{137}Cs	^{155}Eu	U
X												
Y 0	*	*	2.1×10^{-1}	1.9×10^{0}	<200/25	*	1.2×10^{-1}	*	3.3×10^{-2}	5.4×10^{-1}	*	2.1×10^{-1}
15	*	*	1.9×10^{0}		<200/20	*	*	*	*	*	*	
25	*	*	2.8×10^{0}		<200/10	3.1×10^{-1}	1.1×10^{-1}	*	*	1.1×10^{0}	2.2×10^{-1}	
Z 0	*	*	7.0×10^{-1}		<200/20	1.3×10^{0}	1.3×10^{0}	1.2×10^{0}	5.0×10^{-2}	6.5×10^{-1}	*	
BB 20	*	*	2.2×10^{-2}	2.4×10^{0}	<200/10	*	*	*	*	*	*	1.5×10^{-1}
CC 15	*	*	3.1×10^{-1}	3.9×10^{0}	<200/10	*	*	*	*	6.8×10^{-2}	*	1.8×10^{-1}
20	*	*	2.6×10^{-2}	1.4×10^{1}	<200/15	7.2×10^{-1}	*	*	*	8.4×10^{-2}	*	1.2×10^{-1}
DD 0	*	*	2.7×10^{-1}	8.5×10^{-1}	<200/20	1.5×10^{0}	1.6×10^{0}	3.3×10^{-1}	*	9.3×10^{-1}	*	3.1×10^{-1}
10	*	*	*		<200/15	*	*	*	*	5.8×10^{-2}	3.3×10^{-1}	
20	*	*	2.8×10^{-2}		<200/5	*	3.5×10^{-2}	*	*	2.7×10^{-2}	*	

* Less than analytical detection limits.
Blank denotes that data are not available.
Data for test holes A and B for the 107-KE Basin and A and D for the 107-KW Basin not reported.
+ P-11 = a beta/gamma pancake probe for field measurements.
scaler = bench top laboratory count rate meter with a shielded probe for increased sensitivity.
cpm = instrumental measurement in counts per minute.

Table 3-17. Concentrations of Radionuclides Detected in 116-K-1 and 116-K-2 Waste Site Surface Soils for the 1987 Environmental Surveillance Report (WHC 1987).

Sample location	Type	^{60}Co	^{90}Sr	^{137}Cs	^{238}Pu	$^{239/240}Pu$
K-1	Soil	4.5E+0	6.5E-1	2.7E+0	9.4E-3	2.2E-1
K-2	Soil	5.5E-1	1.4E-1	8.0E-1	<5.4E-4	9.2E-3
K-3	Soil	3.5E-1	2.8E-1	9.8E-1	<4.7E-4	6.7E-3
K-4	Soil	2.0E-1	1.0E-1	5.2E-1	<1.1E-4	1.0E-2
K-5	Soil	3.7E-1	9.8E-0	1.3E-0	2.9E-3	3.0E-2

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Table 3-18. Estimated Background Concentrations for Selected Constituents in Hanford Ground Water.

Constituent	Detection Limit[a]	Background Concentration[a]
Aluminum	2[b]	<2[b]
Ammonia	50	<50
Arsenic	0.2[b]	3.9 ±2.4[b]
Barium	6	42 ±20
Beryllium	0.3[b]	0.3[b]
Bismuth	0.02[b]	<0.02[b]
Boron	50[b]	<50[b]
Cadmium	0.2[b]	<0.2[b]
Calcium	50	40,400 ±10,300
Chloride	500	10,300 ±6,500
Chromium	2[b]	4.0 ±2.0[b]
Copper	1[b]	<1[b]
Cyanide	10	<10
Fluoride	500	370 ±100
Lead	0.5[b]	<0.5[b]
Magnesium	10	11,800 ±3,400
Manganese	5	7 ±5
Mercury	0.1	<0.1
Nickel	4[b]	<4[b]
Phosphate	1000	<1,000
Potassium	100	4,950 ±1,240
Selenium	2[b]	<2[b]
Silver	10	<10
Sodium	10	18,260 ±10,150
Strontium	20	236 ±102
Sulfate	500	34,300 ±16,900
Uranium	0.5[c]	1.7 ±0.8[c]
Vanadium	5	17 ±9
Zinc	5	6 ±2
Alkalinity	--	123,000 ±21,000
pH	--	7.64 ±0.16
Total Organic Carbon	200	586 ±347
Conductivity	1[d]	380 ±82[d]
Gross Alpha	0.5[c]	2.5 ±1.4[c]
Gross Beta	4[c]	19 ±12[c]
Radium	0.2[c]	0.2[c]
Tritium		200[c]

[a]Units in ppb unless otherwise noted
[b]Based on ICP/MS data
[c]Units in pCi/L
[d]Units in µmho/cm

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Table 3-19. Ground Water Temperature in Selected 100-K Monitoring Wells.
(sheet 1 of 2)

Well name	Date	Temperature °C	Temperature °F
1-K-11	12/16/76	17.3	63.1
	03/14/79	17.4	63.3
	01/11/85	18.4	65.1
	03/01/85	17.2	63.0
	04/29/85	17.9	64.2
	10/17/85	18.0	64.4
	12/03/85	17.8	64.0
	04/23/87	18.0	64.4
	07/28/87	15.0	59.0
	02/16/89	18.0	64.4
1-K-19	12/16/76	19.3	66.7
	03/14/79	20.6	69.1
	11/01/79	22.2	72.0
	01/11/80	22.3	72.1
	02/19/85	24.0	75.2
	05/09/85	23.0	73.4
	11/01/85	23.6	74.5
	11/15/85	23.3	73.9
	03/06/87	23.0	73.4
	04/21/87	25.0	77.0
	07/28/87	16.0	60.8
	02/16/89	24.0	75.2
1-K-20	12/16/76	21.4	70.5
	03/14/79	20.4	68.7
	01/11/80	21.6	70.9
	02/19/85	21.5	70.7
	05/09/85	21.1	70.0
	09/16/85	20.5	68.9
	09/16/85	20.6	69.1
	11/15/85	20.6	69.1
	03/18/87	20.0	68.0
	04/23/87	24.0	75.2
	07/28/87	16.0	60.8
	02/16/89	22.0	71.6
1-K-22	12/16/76	20.8	69.4
	03/14/79	20.4	68.7
	02/19/85	22.4	72.3
	05/09/85	22.1	71.8
	11/01/85	23.5	74.3
	11/15/85	22.1	71.8
	04/23/87	23.0	73.4
	07/28/87	17.0	62.6
	10/20/87	21.0	69.8
	02/16/89	20.0	68.0
1-K-27	03/01/85	17.1	62.8
	04/29/85	16.7	62.0
	09/14/85	16.4	61.5
	10/17/85	17.7	63.9
	12/03/85	16.4	61.5
	04/23/87	17.0	62.6
	07/29/87	15.0	59.0
	10/16/87	15.0	59.0
	02/14/89	16.0	60.8

Table 3-19. Ground Water Temperature in Selected 100-K Monitoring Wells. (sheet 2 of 2)

Well name	Date	Temperature °C	Temperature °F
1-K-28	04/29/85	18.1	64.6
	09/14/85	17.2	63.0
	10/17/85	18.0	64.4
	04/22/87	18.0	64.4
	07/29/87	15.0	59.0
	02/14/89	17.0	62.6
1-K-29	05/21/85	18.6	65.5
	09/14/85	17.2	63.0
	10/18/85	18.0	64.4
	12/03/85	22.1	71.8
	04/22/87	18.0	64.4
	07/31/87	16.0	60.8
	10/16/87	17.0	62.6
	02/14/89	17.0	62.6
1-K-30K	04/29/85	16.5	61.7
	09/12/85	17.3	63.1
	09/13/85	16.9	62.4
	09/17/85	17.3	63.1
	12/03/85	17.0	62.6
	03/19/87	16.0	60.8
	04/22/87	17.0	62.6
	07/31/87	16.0	60.8
	02/14/89	16.0	60.8
6-66-64	12/16/76	15.8	60.4
	03/14/79	15.9	60.6
	01/11/80	14.9	58.8
	03/25/85	17.7	63.9
	08/03/85	17.4	63.3
	09/21/85	17.2	63.0
	12/16/85	17.1	62.8
6-72-73	12/16/76	18.7	65.7
	03/14/79	17.7	63.9
	01/11/80	17.1	62.8
	10/19/85	17.8	64.0
	02/29/88	15.0	59.0
	06/24/88	18.0	64.4

Source: Hanford Groundwater Database.

Table 3-20. Tritium Concentrations in Selected 100-K Area Ground Water Monitoring Wells. (sheet 1 of 4)

Date	pCi/L	Date	pCi/L	Date	pCi/L
Well K27		Well K28		Well K29	
08/22/81	4,800	08/22/81	7,500	08/22/81	8,500
02/26/82	6,600	11/06/81	6,000	11/06/81	7,900
05/21/82	4,100	02/26/82	3,000	02/26/82	12,000
11/03/82	2,900	05/21/82	3,300	05/21/82	7,500
03/03/83	2,600	11/03/82	4,000	11/03/82	6,000
05/24/83	2,600	03/03/83	1,900	03/03/83	8,200
08/05/83	3,000	05/24/83	2,600	05/24/83	7,200
11/02/83	4,300	08/05/83	2,000	08/05/83	10,000
03/03/84	2,700	11/02/83	1,700	11/02/83	56,000
05/30/84	3,800	03/03/84	2,100	03/03/84	46,000
08/28/84	2,800	05/30/84	2,700	05/30/84	58,000
11/29/84	2,500	08/28/84	2,700	08/28/84	42,000
03/02/85	2,600	11/29/84	2,300	11/29/84	51,000
04/30/85	1,800	03/02/85	3,800	03/02/85	59,000
09/15/85	1,400	04/30/85	4,400	04/30/85	50,000
12/04/85	1,500	09/15/85	2,100	09/15/85	42,000
01/11/86	920	12/04/85	3,900	12/04/85	46,000
04/15/86	1,400	01/11/86	1,800	01/11/86	50,000
09/05/86	2,070	04/15/86	2,200	04/15/86	47,000
10/18/86	707	09/05/87	4,470	09/05/86	5,300
01/14/87	1,910	10/18/86	4,210	10/18/86	5,740
04/24/87	1,650	01/14/87	4,420	01/14/87	16,000
07/30/87	1,350	04/23/87	5,210	04/23/87	12,400
10/17/87	1,670	07/30/87	4,080	07/30/87	8,710
01/19/88	2,740	10/17/87	2,980	10/17/87	6,960
04/13/88	1,850	01/19/88	3,050	01/19/88	10,800
06/14/89	53,700	04/13/88	3,290	04/13/88	17,000
06/14/89	52,600	06/13/89	2,290	06/13/89	11,200
				06/13/89	11,000

Table 3-20. Tritium Concentrations in Selected 100-K Area Ground Water Monitoring Wells. (sheet 2 of 4)

Date	pCi/L	Date	pCi/L	Date	pCi/L
Well K30		Well K11		Well K11 (cont)	
08/22/81	550,000	03/05/80	20,000	10/16/87	515
11/06/81	1,000,000	05/22/80	9,300	01/18/88	537
02/26/82	460,000	08/08/80	13,000	04/12/88	471
05/21/82	480,000	11/19/80	7,500	06/12/89	3,660
11/03/82	1,700,000	05/30/81	6,700	Well 6-66-64	
03/03/83	630,000	08/21/81	6,000	02/29/80	2,400
05/24/83	790,000	11/05/81	4,100	05/29/80	1,600
08/05/83	600,000	02/25/82	4,600	08/12/80	2,300
11/02/83	710,000	05/20/82	2,900	11/07/80	1,600
03/03/84	360,000	11/02/82	1,500	02/23/81	2,200
05/30/84	450,000	03/02/83	14,000	05/20/81	1,800
08/28/84	470,000	05/23/83	2,000	08/26/81	2,100
11/29/84	420,000	08/04/83	2,600	11/03/81	2,100
03/02/85	410,000	11/01/83	2,100	02/24/82	1,800
04/30/85	490,000	03/02/84	2,500	05/11/82	1,900
09/15/85	420,000	05/23/84	1,400	10/29/82	2,600
12/04/85	360,000	08/27/84	1,500	02/25/83	3,100
01/11/86	350,000	11/28/84	2,000	05/10/83	3,300
04/15/86	820,000	03/01/85	2,400	08/12/83	4,700
09/05/86	460,000	04/29/85	3,500	12/12/83	4,500
10/18/86	913,000	10/17/85	2,200	02/24/84	4,900
01/14/87	596,000	12/03/85	3,000	06/09/84	2,400
04/23/87	634,000	01/10/86	1,700	09/23/84	2,400
07/30/87	730,000	04/14/86	1,800	12/17/84	7,900
10/17/87	1,300,000	07/29/86	1,100	03/25/85	7,000
01/19/88	1,180,000	10/16/86	3,420	08/03/85	6,700
04/13/88	1,220,000	01/13/87	2,380	09/21/85	5,900
06/13/89	570,000	04/23/87	1,870	12/15/85	5,700
06/13/89	587,000	07/28/87	1,370	03/26/86	5,100

Table 3-20. Tritium Concentrations in Selected 100-K Area Ground Water Monitoring Wells. (sheet 3 of 4)

Date	pCi/L	Date	pCi/L	Date	pCi/L
Well 6-66-64 (cont)		Well 6-72-73 (cont)		Well K19	
05/28/86	6,300	09/29/88	1,850	05/12/86	13,000
09/26/86	7,800	01/18/89	1,280	06/23/86	7,800
11/05/86	6,200	Well K19		07/10/86	7,400
01/30/87	6,420	03/05/80	2,800	08/04/86	7,600
06/17/87	6,510	05/22/80	3,600	09/04/86	8,660
08/26/87	9,300	08/08/80	2,800	10/07/86	8,900
11/08/87	6,490	11/19/80	3,800	11/05/86	9,070
01/26/88	6,850	05/30/81	20,000	12/09/86	8,450
04/27/88	5,870	08/21/81	11,000	01/13/87	9,850
07/21/88	5,870	11/05/81	2,400	02/13/87	6,600
11/17/88	6,040	02/25/83	22,000	03/06/87	7,420
04/19/89	6,070	05/20/82	40,000	05/06/87	9,640
Well 6-72-73		11/02/82	2,300	06/16/87	7,080
05/28/80	1,200	03/02/83	49,000	07/28/87	4,790
11/07/80	1,300	05/20/83	6,300	08/11/87	6,370
05/27/81	1,400	08/04/83	35,000	09/08/87	2,500
11/05/81	1,200	11/04/83	24,000	10/13/87	4,490
05/12/82	1,100	03/02/84	31,000	11/08/87	5,100
10/28/82	1,700	05/23/84	23,000	12/03/87	5,250
05/13/83	1,100	08/27/84	14,000	01/18/88	3,260
11/09/83	2,100	11/28/87	15,000	02/03/88	3,130
06/09/84	1,300	02/19/85	30,000	03/17/88	2,840
12/07/84	1,800	05/09/85	30,000	04/12/88	3,300
10/19/85	1,300	11/01/85	17,000	05/04/88	4,260
04/01/86	920	11/16/85	20,000	06/06/88	4,640
09/30/86	2,780	01/10/86	12,000	Well K20	
06/16/87	3,250	02/05/86	13,000	03/05/80	3,100
08/20/87	2,350	03/12/86	13,800	05/22/80	1,600
02/29/88	1,670	04/11/86	17,000	08/08/80	2,000

Table 3-20. Tritium Concentrations in Selected 100-K Area Ground Water Monitoring Wells. (sheet 4 of 4)

Date	pCi/L	Date	pCi/L	Date	pCi/L
Well K20 (cont)		Well K20 (cont)		Well K22 (cont)	
11/19/80	1,900	10/20/87	1,020	05/09/85	940
05/30/81	4,400	01/18/88	1,380	11/01/85	1,300
08/21/81	2,300	04/12/88	1,060	11/16/85	1,200
11/05/81	2,000	Well K22		01/10/86	310
02/25/82	1,600	03/05/80	1,700	04/11/86	1,000
05/20/82	1,200	05/22/80	1,600	07/30/86	640
11/02/82	540	08/08/80	1,400	10/16/86	859
03/02/83	1,300	11/19/80	1,700	01/13/87	730
05/20/83	1,200	08/21/81	1,500	01/13/87	793
08/04/83	1,500	11/05/81	1,500	01/13/87	805
11/04/83	2,000	02/25/82	1,200	04/23/87	673
03/02/84	930	05/20/82	930	04/23/87	1,190
05/23/84	1,300	11/02/82	900	04/23/87	2,240
08/27/84	1,100	03/02/83	910	07/28/87	552
11/28/84	1,200	05/20/83	820	07/28/87	682
02/19/85	2,400	08/04/83	1,400	07/28/87	1,080
05/09/85	4,300	11/04/83	1,400	10/20/87	590
09/16/85	1,400	03/02/84	980	10/20/87	728
11/16/85	1,300	05/23/84	710	01/18/88	700
01/10/86	890	08/27/84	590	01/18/88	862
04/11/86	1,300	11/28/84	1,100	04/12/88	815
07/30/86	1,200	02/19/85	1,800		
10/16/86	1,390				
01/13/87	886				
04/23/87	1,210				
07/28/87	885				

Table 3-21. Available Analysis Data Nitrate Occurrence in Ground Water Monitoring Wells 100-K Area and Vicinity. (sheet 1 of 2)

Date	ppm	Date	ppm	Date	ppm
Well 1-K-11		Well 1-K-28 (cont)		Well 6-66-64	
03/01/85	49.0	04/22/87	23.0	03/25/85	21.0
04/29/85	41.0	07/29/87	22.0	08/03/85	35.0
10/17/85	78.0	01/18/88	18.3	09/21/85	32.0
12/03/85	110.0	04/12/88	20.4	12/15/85	45.0
01/10/86	100.0	02/14/89	22.6	03/26/86	24.0
04/14/86	66.0	06/12/89	23.5	05/28/86	32.0
07/29/86	63.2	10/16/89	25.0	09/26/86	15.8
10/16/86	52.0	02/28/90	21.4	11/05/86	10.3
01/13/87	54.6	Well 1-K-29		01/30/87	14.5
04/23/87	50.9	01/13/87	13.7	06/17/87	14.2
04/23/87	48.9	04/22/87	11.8	08/26/87	26.5
07/28/87	48.2	04/22/87	11.7	11/08/87	15.5
01/18/88	49.9	07/31/87	8.5	01/26/88	15.1
04/12/88	47.9	10/16/87	9.0	04/27/88	15.8
802/16/89	38.0	01/18/88	8.6	07/21/88	16.7
06/12/89	37.0	04/12/88	9.3	11/17/88	18.1
10/16/89	38.0	02/14/89	9.1	04/19/89	22.5
03/02/90	31.9	06/12/89	8.1	10/23/89	23.5
Well 1-K-27		10/16/89	8.0	Well 6-72-73	
01/13/87	9.1	03/05/90	9.5	10/19/85	14.0
04/23/87	8.9	Well 1-K-30		04/01/86	9.7
04/23/87	8.7	09/13/85	43.6	09/30/86	7.9
07/29/87	7.0	01/13/87	44.6	06/16/87	4.8
10/16/87	7.5	03/19/87	57.0	08/20/87	3.9
01/18/88	11.1	04/22/87	58.5	02/29/88	4.0
04/12/88	7.9	04/22/87	51.7	02/29/88	4.1
02/14/89	3.0	07/31/87	49.0	06/24/88	4.1
06/13/89	7.7	01/18/88	66.0	09/29/88	4.1
10/16/89	9.0	04/12/88	70.1	01/18/89	4.5
02/28/90	5.1	02/14/89	43.4		
Well 1-K-28		06/12/89	42.9		
01/13/87	27.1	10/17/89	66.0		
04/22/87	23.4	03/02/90	42.3		

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Table 3-22. Hexavalent Chromium Concentrations in Select 100-K Area Ground Water Monitoring Wells (ppb).

Well Number	Date Sampled	Concentration
K-11	04/24/87	29.0 (1)
K-19	03/07/87	100.0 (1)
	04/22/87	97.0 (1)
	07/29/87	101.0 (1)
K-20	09/17/85	152.0
	09/17/85	171.0
	09/17/85	173.0
	03/19/87	137.0 (1)
	04/24/87	146.0 (1)
	07/29/87	141.0 (1)
K-22	04/24/87	193.0 (1)
	07/29/87	186.0 (1)
	10/21/87	231.0 (1)
K-27	04/24/87	<10.0 (1)
	07/29/87	<10.0 (1)
	10/21/87	<10.0 (1)
	02/15/89	<10.0 (1)
K-28	04/23/87	<10.0 (1)
	07/30/87	<10.0 (1)
	02/15/89	<10.0 (1)
K-30	03/20/87	<10.0 (1)
	04/23/87	<10.0 (1)
	08/01/87	<10.0 (1)
	02/15/89	<10.0 (1)
6-70-68	12/22/87	<10.0 (1)
	03/01/88	<10.0 (1)
	06/23/88	<10.0 (1)
	08/31/88	<10.0 (1)
6-72-73	03/01/88	<10.0 (1)
	06/25/88	<10.0 (1)
6-73-61	12/14/87	17.0 (1)
	03/01/88	15.0 (1)
	06/21/88	12.0 (1)
	08/31/88	17.0 (1)
	01/20/89	11.0 (1)
6-78-62	03/03/88	106.0 (1)
	07/01/88	88.0 (1)
	01/20/89	81.0 (1)

(1)Filtered analysis method
threshold = 50 ppb

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Table 3-23. Radionuclide Concentrations Measured in Columbia River Water at Priest Rapids Dam, Upstream of the 100-K Area in 1988 (Jaquish and Bryce 1989).

Radionuclides[b]	No. of samples	Concentrations (pCi/L)[a] Maximum	Minimum	Average	Drinking water standard[c]
			Composite System		
Gross alpha	12	0.85 ± 0.81	-0.7 ± 0.20	0.31 ± 0.17	15
Gross beta	12	2.31 ± 1.00	0.06 ± 1.00	0.96 ± 0.48	50
Tritium	12	89 ± 6	56 ± 4	70 ± 6	20,000
^{89}Sr	12	0.184 ± 0.084	-0.044 ± 0.072	0.019 ± 0.038	20
^{90}Sr	12	0.15 ± 0.03	0.05 ± 0.03	0.10 ± 0.02	8
^{234}U	12	0.27 ± 0.06	0.11 ± 0.03	0.20 ± 0.03	--[d]
^{235}U	12	0.014 ± 0.013	-0.003 ± 0.008	0.006 ± 0.003	--[d]
^{238}U	12	0.21 ± 0.004	0.11 ± 0.03	0.17 ± 0.02	--[d]
Total Uranium	12	0.48 ± 0.07	0.23 ± 0.05	0.37 ± 0.04	--[d]
			Continuous System		
^{60}Co P	20	0.0018 ± 0.019	-0.0012 ± 0.029	-0.0006 ± 0.0008	100
D	20	0.0042 ± 0.041	-0.0027 ± 0.0042	-0.0009 ± 0.0011	
^{129}I D	4	0.000045 ± 0.000005	0.000006 ± 0.0000001	0.000017 ± 0.000019	
^{131}I P	11	0.0026 ± 0.0037	-0.0011 ± 0.0043	0.0008 ±	3
D	11	0.0038 ± 0.0073	0.0068 ± 0.0114	-0.0007 ± 0.0023	
^{137}Cs P	20	0.004 ± 0.0024	0.0002 ± 0.0010	0.0018 ± 0.0005	200
D	20	0.0067 ± 0.0040	-0.0019 ± 0.0040	0.0028 ± 0.0011	
$^{238/239}Pu$ P	4	0.00010 ± 0.00008	0.000002 ± 0.000007	0.00006 ± 0.00005	--[d]
D	4	0.00010 ± 0.00016	0.00002 ± 0.00005	0.00006 ± 0.00004	

[a] Maximum and minimum values ± sigma counting error; average ± 2 standard error of the calculated mean; it is not uncommon for individual measurements of environmental radioactivity to result in values of zero or negative numbers from subtracting out instrumental background.

[b] Radionuclides measured using the continuous system show the particulate (P) and dissolved (D) fractions separately; other radionuclides are based on samples collected by the composite system.

[c] WAC 248 and 40 CFR 141.

[d] Dashes indicate no drinking water standard.

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Table 3-24. Nonradiological Water Quality Data for the Columbia River Upstream of the 100-K Area in 1988 (Jaquish and Bryce 1988).

Analyses	Units	No. of samples	Maximum	Minimum	Annual average[a]	State standards[b]
Pacific Northwest Laboratory environmental monitoring						
pH	-	12	8.5	7.4	NA	6.5 to 8.5
Fecal coliform #/100 mL		12	130.0	2.0	2[c]	100
Total coliform	#/100 mL	12	1,600.0	2.0	48[c]	NA
Biological oxygen demand	mg/L	12	5.2	0.7	2.1 ± 0.8	NA
Nitrate	mg/L	12	0.23	0.05	0.14 ± 0.03	NA
U.S. Geological Survey sampling program[d]						
Temperature[e]	^{o}C	365	19.6	1.8	11.3	20 (maximum)
Dissolved oxygen	mg/L	6	13.4	8.8	11.5 ± 1.4	8 (minimum)
Turbidity	NTU[f]	6	1.8	0.4	1.0 ± 0.4	5 + background
pH	--	6	8.8	8.0	NA	6.5 to 8.5
Fecal coliform	#/100 mL	6	3.0	<1.0	2[3]	100
Suspended solids, 105°C	mg/L	NR				NA
Dissolved solids, 180°C	mg/L	6	88.0	71.0	81 ± 6	NA
Specific conductance	µmhos/cm	6	162.0	123.0	140 ± 15	NA
Hardness, as $CaCO_3$	mg/L	6	77.0	58.0	68 ± 7	NA
Phosphorus, total	mg/L	6	0.03	0.02	0.023 ± 0.004	NA
Chromium, dissolved	µg/L	3	<1.0	<1.0	<1.0	NA
Nitrogen, Kjeldahl	mg/L	6	0.5	<0.2	0.28 ± 0.11	NA
Total organic carbon	mg/L	4	2.8	1.4	2.1 ± 0.7	NA
Iron dissolved	µg/L	3	65.0	9.0	28 ± 37	NA
Ammonia, dissolved (as N)	mg/L	6	0.05	<0.01	0.02 ± 0.02	NA

a Average values ±2 standard error of the calculated mean.
b WAC 173-201.
c Annual median.
d Provisional data subject to revision.
e Maximum and minimum represent daily averages.
f Nephelometric turbidity units.
NA Not applicable.
NR Not reported.

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Table 3-25. Radionuclide Concentrations in Water Samples Taken at the 300 Area Water Intake in 1988 (Jaquish and Bryce 1989).

Radionuclides[b]		No. of samples	Concentrations (pCi/L)[a] Maximum	Minimum	Average	Drinking water standard[c]
Composite System						
Gross alpha		4	0.76 ± 0.48	0.38 ± 0.42	0.52 ± 0.17	15
Gross beta		4	1.55 ± 1.24	0.37 ± 1.21	1.02 ± 0.54	20
Tritium		3	170 ± 6	128 ± 6	148 ± 24	20,000
^{89}Sr		4	0.110 ± 0.107	-0.073 ± 0.133	0.016 ± 0.079	20
^{90}Sr		4	0.14 ± 0.04	0.09 ± 0.03	0.12 ± 0.02	8
^{234}U		4	0.33 ± 0.05	0.21 ± 0.05	0.27 ± 0.05	--[d]
^{235}U		4	0.009 ± 0.013	0.002 ± 0.008	0.006 ± 0.003	--[d]
^{238}U		4	0.24 ± 0.05	0.18 ± 0.5	0.20 ± 0.02	--[d]
Total Uranium		4	0.58 ± 0.07	0.41 ± 0.07	0.48 ± 0.07	--[d]
Continuous System						
^{60}Co	P	23	0.0023 ± 0.0012	-0.0003 ± 0.0009	0.0010 ± 0.0003	100
	D	23	0.0063 ± 0.0045	-0.0003 ± 0.00032	-0.0026 ± 0.0007	
^{129}I	D	4	0.00011 ± 0.00001	0.000054 ± 0.000006	0.00000 ± 0.00003	1
^{131}I	P	14	0.0020 ± 0.0030	0.0015 ± 0.0032	0.0002 ± 0.0006	3
	D	14	0.0114 ± 0.0055	0.0020 ± 0.0078	-0.0015 ± 0.0021	
^{137}Cs	P	23	0.0037 ± 0.0028	-0.0002 ± 0.0007	0.0014 ± 0.0005	200
	D	23	0.0066 ± 0.0028	0.0000 ± 0.0014	0.0035 ± 0.0007	
$^{239/249}Pu$	P	4	0.00005 ± 0.00004	0.00001 ± 0.00001	0.00003 ± 0.00002	--[d]
	D	4	0.00003 ± 0.00005	0.00003 ± 0.0	0.00001 ± 0.00001	

[a] Maximum and minimum values ± sigma counting error; average ± 2 standard error of the calculated mean; it is not uncommon for individual measurements of environmental radioactivity to result in values of zero or negative numbers from subtracting out instrumental background.

[b] Radionuclides measured using the continuous system show the particulate (P) and dissolved (D) fractions separately; other radionuclides are based on samples collected by the composite system.

[c] WAC 248 and 40 CFR 141.

[d] Dashes indicate no drinking water standard.

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Table 3-26. Radionuclide Concentrations for the Columbia River at the City of Richland pumphouse in 1988 (Jaquish and Bryce 1989).

Radionuclides[b]	No. of samples	Concentrations (pCi/L)[a] Maximum	Minimum	Average	Drinking water standard[c]
Composite System					
Gross alpha	12	0.76 ± 0.42	-0.4 ± 0.23	0.29 ± 0.13	15
Gross beta	12	1.62 ± 1.23	-0.02 ± 0.89	0.87 ± 0.29	50
Tritium	12	160 ± 7	98 ± 5	132 ± 10	20,000
^{89}Sr	12	0.098 ± 0.083	-0.72 ± 0.68	0.002 ± 0.28	20
^{90}Sr	12	0.17 ± 0.03	0.08 ± 0.03	0.12 ± 0.02	3
^{234}U	12	0.28 ± 0.05	0.04 ± 0.02	0.22 ± 0.04	--[d]
^{235}U	12	0.044 ± 0.020	-0.005 ± 0.000	0.009 ± 0.007	--[d]
^{238}U	12	0.25 ± 0.05	0.07 ± 0.03	0.18 ± 0.03	--[d]
Total Uranium	12	0.57 ± 0.07	0.11 ± 0.04	0.41 ± 0.07	--[d]
Continuous System					
^{60}Co P	23	0.0059 ± 0.0038	-0.0022 ± 0.0013	-0.0014 ± 0.0005	100
^{60}Co D	23	0.0113 ± 0.0071	-0.0010 ± 0.0036	0.0029 ± 0.0011	
^{129}I D	4	0.00014 ± 0.00002	0.000069 ± 0.000007	0.00010 ± 0.00003	1
^{131}I P	12	0.0022 ± 0.0025	-0.0011 ± 0.0034	0.0005 ± 0.0006	3
^{131}I D	12	0.0101 ± 0.0164	-0.0116 ± 0.0205	0.0011 ± 0.0033	
^{137}Cs P	23	0.0057 ± 0.0017	-0.0004 ± 0.0014	-0.0019 ± 0.0005	200
^{137}Cs D	23	0.0130 ± 0.0059	-0.0012 ± 0.0034	0.0031 ± 0.0014	
$^{239/240}Pu$ P	4	0.00013 ± 0.00006	-0.00002 ± 0.00001	0.00007 ± 0.00005	--[d]
$^{239/240}Pu$ D	4	0.00005 ± 0.00011	0.00005 ± 0.000057	0.00003 ± 0.00003	

[a] Maximum and minimum values ± sigma counting error; average ± 2 standard error of the calculated mean; it is not uncommon for individual measurements of environmental radioactivity to result in values of zero or negative numbers from subtracting out instrumental background.
[b] Radionuclides measured using the continuous system show the particulate (P) and dissolved (D) fractions separately; other radionuclides are based on samples collected by the composite system.
[c] WAC 248 and 40 CFR 141.
[d] Dashes indicate no drinking water standard.

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Table 3-27. Nonradiological Water Quality Data for the Columbia River at the Richland pumphouse in 1988 (Jaquish and Bryce 1989).

Analyses	Units	No. of samples	Maximum	Minimum	Annual average[a]	State standard[b]
Pacific Northwest Laboratory environmental monitoring						
pH	-	12	8.3	7.3	NA	6.5 to 8.5
Fecal coliform	#/100 mL	12	70.0	2.0	7[c]	100
Total coliform	#/100 mL	12	240.0	9.0	70[c]	NA
Biological oxygen demand	mg/L	12	2.5	0.7	1.7 ± 0.4	NA
Nitrate	mg/L	12	1.1	0.06	0.3 ± 0.2	NA
U.S. Geological Survey sampling program[d]						
Temperature[e]	°C	365	20.0	1.4	11.6	20 (maximum)
Dissolved oxygen	mg/L	4	13.2	10.3	11.7 ± 1.5	8 (minimum)
Turbidity	NTU[f]	3	1.5	0.6	1.0 ± 0.6	5 + background
pH	--	4	8.7	7.9	NA	6.5 to 8.5
Fecal coliform	#/100 mL	4	8.0	<1.0	7[c]	100
Suspended solids, 105°C	mg/L	3	4.0	<1.0	<2.7 ± 1.8	NA
Dissolved solids, 180°C	mg/L	3	91.0	74.0	83 ± 10	NA
Specific conductance	µmhos/cm	4	156.0	122.0	139 ± 17	NA
Hardness, as $CaCO_3$	mg/L	3	76.0	62.0	71 ± 9	NA
Phosphorus, total	mg/L	3	0.03	0.02	0.023 ± 0.007	NA
Chromium, dissolved	µg/L	3	<1.0	<1.0	<1.0	NA
Nitrogen, Kjeldahl	mg/L	3	0.3	<0.2	0.27 ± 0.07	NA
Total organic carbon	mg/L	4	3.1	1.3	2.2 ± 0.8	NA
Iron dissolved	µg/L	3	8.0	4.0	5.3 ± 2.7	NA
Ammonia, dissolved (as N)	mg/L	3	0.04	<0.01	0.03 ± 0.02	NA

a Average values ±2 standard error of the calculated mean.
b WAC 173-201.
c Annual median.
d Provisional data subject to revision.
e Maximum and minimum represent daily averages.
f Nephelometric turbidity units.
NA Not applicable.

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Table 3-28. Radionuclide Concentrations in Sediments Collected at Priest Rapids Dam and McNary Dam in 1988 (Jaquish and Bryce 1989).

Locations	Radionuclides	No. of samples	Concentration (pCi/L)[a]		
			Maximum	Minimum	Average
Priest Rapids Dam	^{60}Co	4	0.014 ± 0.018	-0.012 ± 0.012	0.003 ± 0.012
	^{90}Sr	4	0.072 ± 0.006	0.0048 ± 0.0037	0.026 ± 0.031
	^{134}Cs	3	0.0098 ± 0.018	-0.0021 ± 0.011	0.0049 ± 0.0072
	^{137}Cs	4	0.28 ± 0.03	0.24 ± 0.02	0.26 ± 0.02
	^{235}U[b]	4	0.097 ± 0.15	0.007 ± 0.012	0.063 ± 0.042
	^{238}U[b]	4	0.79 ± 0.38	0.67 ± 0.36	0.73 ± 0.05
	^{238}Pu	4	0.00026 ± 0.00017	0.00004 ± 0.00006	0.00015 ± 0.00009
	$^{239/240}Pu$	4	0.0028 ± 0.0007	0.0015 ± 0.0003	0.0023 ± 0.0006
McNary Dam	^{60}Co	4	0.36 ± 0.03	0.15 ± 0.03	0.27 ± 0.11
	^{90}Sr	4	0.058 ± 0.006	0.036 ± 0.005	0.046 ± 0.009
	^{134}Cs	3	0.057 ± 0.021	0.030 ± 0.014	0.044 ± 0.016
	^{137}Cs	4	0.79 ± 0.05	0.63 ± 0.04	0.69 ± 0.07
	^{235}U[b]	4	0.22 ± 0.14	-0.09 ± 0.16	0.05 ± 0.13
	^{238}U[b]	4	0.89 ± 0.49	0.63 ± 0.31	0.78 ± 0.12
	^{238}Pu	4	0.00059 ± 0.00028	0.00020 ± 0.00020	0.00043 ± 0.00018
	$^{239/240}Pu$	4	0.011 ± 0.001	0.009 ± 0.001	0.010 ± 0.001

a Maximum and minimum values ± sigma counting error; average ±2 standard error of the calculated mean.

b ^{235}U and ^{238}U by low-energy photon detector (LEPD) method.

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Table 3-29. Radionuclide Concentrations in Aquatic Fauna Above and Below the 100-K Area (Jaquish and Bryce 1989).

Type/Location	^{60}Co pCi/g wet weight[a]			^{90}Sr pCi/g wet weight[a]			^{137}Cs pCi/g wet weight[a]		
	No. of samples	Maximum	Average	No. of samples	Maximum	Average	No. of samples	Maximum	Average
Whitefish muscle/ upstream of site boundary	5	0.011 ± 0.023	0.005 ± 0.006	5	0.003 ± 0.003	0.001 ± 0.001	5	0.014 ± 0.021	0.008 ± 0.010
100-K Area vicinity	10	0.035 ± 0.026	0.016 ± 0.012	10	0.005 ± 0.006	0.001 ± 0.001	10	0.039 ± 0.022	0.023 ± 0.010
Whitefish carcass/ upstream of site boundary	NS[b]	---	---	5	0.054 ± 0.007	0.031 ± 0.016	NS	---	---
100-K Area vicinity	NS	---	---	10	0.064 ± 0.005	0.026 ± 0.009	NS	---	---

[a] Maximum values ±2 sigma counting error. Averages ±2 standard error of the calculated mean.

[b] No sample.

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Table 3-30. Radiological Drinking Water Standards (EPA 1976).

Contaminants	Limits
Gross alpha (excluding uranium)	15 pCi/L
Combined ^{226}Ra and ^{228}Ra	5 pCi/L
Radium-226 (State of Washington only)	3 pCi/L
Gross beta and gamma radioactivity not from manmade radionuclides	Annual average concentration shall produce an annual dose from manmade radionuclides equivalent to the total body or any internal organ dose greater than 4 mrem/yr. If two or more radionuclides are present, the sum of their annual dose equivalent shall not exceed 25 mrem/yr. Compliance may be assumed if annual average concentrations for gross beta activity, ^{3}H, and ^{90}Sr are less than 50, 20, and 8 pCi/L, respectively.

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Table 3-31. Annual/Average Concentrations of Manmade Radionuclides in Drinking Water (EPA 1976).

Radionuclide	Critical organ	Concentration pCi/L
^{3}H	Whole body	20,000
^{60}Co	GI (LLi)[a]	100
^{89}Sr	Bone	20
^{90}Sr	Bone marrow	8
^{95}Zr	GI (LLi)[a]	200
^{95}Nb	GI (LLi)[a]	300
^{106}Ru	GI (LLi)[a]	30
^{129}I	Thyroid	1
^{131}I	Thyroid	3
^{134}Cs	GI (s)[a]	20,000
^{137}Cs	Whole body	200
^{14}C	Fatty tissue	2,000
^{99}Tc	GI (LLi)[a]	900
^{103}Ru	GI (LLi)[a]	200
^{126}Sb	GI (LLi)[a]	300

[a]Gastrointestinal tract (lower large intestine).

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Table 3-32. Washington State Water Quality Standards for the Hanford Reach of the Columbia River.

Parameter	Permissible levels
Fecal coliform organism	- $\leq$100 organisms/100 mL - $\leq$10% of samples may exceed 200 organisms/100 mL
Dissolved oxygen	- >8 mg/L
Temperature	- $\leq 20^{o}$C (68^{o}F) due to human activities. - When natural conditions exceed 20^{o}C, no temperature increase of greater than 0.3^{o}C allowed - Increases not to exceed 34/(T+9), where T = highest existing temperature in ^{o}C outside of dilution zone
pH	- 6.5 to 8.5 range - <0.5 unit induced variation
Turbidity	- <5NTU[a] over background turbidity
Toxic, radioactive, or deleterious materials	- Concentrations shall be below those of public health significance, or which cause acute or chronic toxic conditions to the aquatic biota, or which may adversely affect any water use
Aesthetic value	- Shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch, or taste

[a]NTU=nephelometric turbidity units.
Source: WAC 173-201.

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Table 3-33. Potential Location-Specific ARARs (sheet 1 of 2)

Location	Requirement	Prerequisite	Citation
Within 200 ft of a fault displaced in Holocene time	New treatment, storage, or disposal of hazardous waste prohibited	RCRA hazardous waste; treatment, storage, or disposal within 200 ft of a fault	40 CFR 264.18(a)
Within 100-yr floodplain	Facility must be designed, constructed, operated, and maintained to avoid washout	RCRA hazardous waste; treatment, storage, or disposal within 100-yr floodplain	40 CFR 264.18(b)
Within floodplain	Action to avoid adverse effects, minimize potential harm, restore and preserve natural and beneficial values	Action that will occur in a floodplain such as lowlands and relatively flat areas adjoining inland waters and other flood prone areas	40 CFR 6, App. A: Fish and Wildlife Coordination Act (16 USC 661 et seq.); 40 CFR 6.302(b). 40 CFR 6 subpart A sets EPA policy for carrying out E.O. 11988 and 11990 which are binding on the level of government for which they are issued. 10 CFR 1022 is DOE's policy.
Within area where action may cause irreparable harm, loss, or destruction of significant artifacts.	Action to recover and preserve artifacts	Alteration of terrain that threatens significant scientific, prehistorical, historical or archaeological data.	National Historical Preservation Act (16 USC 469); 36 CFR 65; 25 CFR 261; 43 CFR 3; 43 CFR 7
Historic project owned or controlled by federal agency	Action to preserve historic properties; planning of action to minimize harm to National Historic Landmarks	Property included in or eligible for the National Register of Historic Places	National Historic Preservation Act, Section 106 (16 USC 470 et seq.); 36 CFR 800
Within area where action may impact archeological sites and resources	Action to recover and preserve artifacts. Must secure permission from director	Any site, object, artifact, or location of prehistoric or archaeological interest located in on, or under lands or waters under possession or control the state, county, city, or political subdivision	CW 27.53
Critical habitat upon which endangered species or threatened species depend	Action to conserve endangered species or threatened species, including consultation with the U.S. Fish and Wildlife Service	Determination of presence of endangered or threatened species. Applicable to facilities authorized, funded, or carried out by federal government	Endangered Species Act of 1973 (16 USC 1531 et seq.); 50 CFR 402; 50 CFR 10 et seq.; Fish and Wildlife Coordination Act (16 USC 661 et seq.); 33 CFR 320.3
Wetlands	Action to prohibit discharge of dredged or fill material into wetlands without permit	Discharge of dredged or fill material; wetlands as defined by U.S. Army Corps of Engineers	Clean Water Act Section 404; 40 CFR 230, 33 CFR 320-330
	Action to avoid adverse effects, minimize potential harm, and preserve and enhance wetlands, to the extent possible	Action involving construction of facilities or management of property in wetlands, as defined by 40 CFR 6, App. A, Section 4(j)	40 CFR 6, Appendix A; Executive Order 11990, Protection of Wetlands; 10 CFR 1022 (DOE policy)

Table 3-33. Potential Location-Specific ARARs. (sheet 2 of 2)

Location	Requirement	Prerequisite	Citation
Wildlife refuge	Only actions allowed under the provisions of 16 USC 668dd(c) may be undertaken in areas that are part of the National Wildlife Refuge System	Areas designated part of National Wildlife Refuge System	16 USC 668dd et seq.; 50 CFR 27
Areas affecting stream or river	Action to protect fish or wildlife	Diversion, channeling or other activity that modifies a stream or river and affects fish or wildlife	Fish and Wildlife Coordination Act (16 USC 661 et seq.); 40 CFR 6.302(g)

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Table 3-34. Selected Location-Specific Potential Applicable or Relevant and Appropriate Requirements. (sheet 1 of 2)

Action	Requirements	Prerequisites for Applicability	Citation
CHAPTER 1 - CLEAN AIR ACT			
NAAQs attainment areas	New major stationary sources shall apply best available control technology for each pollutant, subject to regulation under the Act, that the source would have potential to emit in significant amounts	Major stationary sources as identified in 40 CFR section 52.21(b)(1)(i)(a) that emits, or has the potential to emit, 100 tons per year or more of any regulated pollutant; any other stationary source that emits, or has the potential to emit, 250 tons per year or more of any regulated pollutant.40 CFR section 52.21(j) (CAA)	
	Owner or operator of proposed source of modification shall demonstrate that allowable emissions increases or reductions (including secondary emissions) will not cause or contribute to a violation of the NAAQS or applicable maximum allowable increase over baseline concentrations		
NAAQS non-attainment areas	Source must obtain emission offsets in air quality control region of greater than one-to-one	Any stationary facility or source of air pollutants that directly emits, or has the potential to emit, 100 tons per year or more of any air pollutant (including any major emitting facility or source of fugitive emissions of any such pollutants) [CAA section 302(j)]	CAA Part D. section 173(1)
	Source subject to "lowest achievable emission rate (LAER)" as defined in 40 CFR section 51.18(j)(xiii)		CAA Part D, section 173(2)
	All major stationary sources owned or operated by the person in the State are in compliance, or on a schedule for compliance, with all applicable emission standards		CAA Part D, section 173(3)
Other Resource Protection Statutes			
Historic district, site, building, structure, or object	Avoid impacts on cultural resources. Where impacts are unavoidable, mitigate through design and data recovery	Properties listed in the National Register of Historic Places, or eligible for such listing	National Historic Preservation Act (NHPA) 16 CFR Part 470, et. seq.
Critical habitat of/or an endangered or threatened species	Identify activities that may affect listed species	Species or habitat listed as endangered or threatened	Endangered Species Act (ESA) 50 CFR section 402.04
	Actions must not threaten the continued existence of a listed species		50 CFR section 402.01
	Actions must not destroy critical habitat		50 CFR section 402.01

Table 3-34. Selected Location-Specific Potential Applicable or Relevant and Appropriate Requirements. (sheet 2 of 2)

Action	Requirements	Prerequisites for Applicability	Citation
Wild and scenic rivers	Determine if project will affect the free-flowing characteristics, scenic, or natural values of a designated river;	Any river, and the bordering or adjacent land, designated as "wild and scenic or recreational"	Wild and Scenic Rivers Act (WSRA) 36 CFR section 297.4
	Not authorize any water resources project or any other project that would directly or indirectly impact any designated river without notifying DOE or Forest Service		
Coastal zone or an area that will affect the coastal zone	Federal activities must be consistent with, to the maximum extent practicable, State coastal zone management programs	Wetland, flood plain, estuary, beach, dune, barrier island, coral reef, and fish and wildlife habitat, within the coastal zone	Coastal Zone Management Act (CZMA) 15 CFR section 930.30
	Federal agencies must supply the State with a consistency determination		15 CFR section 930.34 (CZMA)
Wilderness area	The following are not allowed in a Wilderness area: ■ commercial enterprises ■ permanent, roads, except as necessary to administer the area ■ motor vehicles ■ motorized equipment ■ motorboats ■ aircraft ■ mechanized transport ■ structures or buildings	Any unit of the National Wildlife Refuge System	Wilderness Act (WA) 50 CFR section 35.5

Table 3-35. Preliminary Contaminants of Concern for the 100-KR-4 Operable Unit.

Potential Contaminants		
B	^{63}Ni	^{238}U
Cr	^{90}Sr	^{238}Pu
Cu	^{134}Cs	^{239}Pu
Pb	^{137}Cs	^{240}Pu
Hg	^{152}Eu	PCBs
NO_3	^{154}Eu	Gross alpha
^{3}H	^{155}Eu	Gross beta
^{14}C	^{235}U	Petrolium products
^{60}Co	^{241}Am	Herbicides
Zn	^{41}Ca	Pesticides
	^{129}I	
	^{99}Te	

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Table 3-36. Half-lives of Selected Radionuclides of Interest to the 100-KR-4 Operable Unit.

Nuclide	Half-life (yrs)
^{3}H	12
^{14}C	5,700
^{41}Ca	10,000
^{60}Co	5
^{129}I	1,600,000
^{63}Ni	92
^{90}Sr	28
^{134}Cs	2
^{137}Cs	33
^{152}Eu	13
^{154}Eu	8
^{155}Eu	5
^{235}U	710,000,000
^{238}U	4,400,000,000
^{238}Pu	90
^{239}Pu	24,000
^{240}Pu	6,600

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Table 3-37. Unitless Bioconcentration Factors for Selected Contaminants of Interest to the 100-KR-4 Operable Unit.[a]

Contaminant	Bioconcentration factor
Carbon	4,600 to 9,100 (invertebrates, fish)
Cesium	0.3 to 16 (birds, mammals)
Cobalt	0.2 to 2 (birds, mammals)
Copper	200 (fish)
Chromium	16 (fish)
Hydrogen	0.6 to 1 (mammals)
Lead	2,000 (invertebrates, fish)
Mercury	5,500 (fish)
Nickel	47 to 100 (invertebrates)
Sodium	100 to 200 (invertebrates, fish)
Strontium	0.2 to 8 (mammals)

[a] This list is not all inclusive and bioconcentration factors are not available for all contaminants of interest.

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4.0 WORK PLAN APPROACH AND RATIONALE

Chapter 4.0 provides the rationale and framework for conducting the Phase I RI for the 100-KR-4 operable unit. This section identifies and evaluates data needs required to complete the RI Phase I. Data uses and data users, data needs, and the DQOs for the sources, vadose, surface water and sediments, ground water, and aquatic biota are defined. Sections 4.1 and 4.2 summarize the essential steps in the decision-making process leading to development of the data collection program. Section 4.3 integrates these steps and discusses them in more detail. The methodology for obtaining and evaluating data is outlined to focus the 100-KR-4 operable unit RI Phase I and provide a preview of needed tasks.

The DQOs are specific qualitative and quantitative statements designed to ensure that data of known and appropriate quality are obtained during the remedial response process. The DQOs are developed for each data collection activity in the remedial response process (RI/FS, remedial design, remedial action). A three-stage process is used to develop DQOs:

- Stage 1--Identify decision types
- Stage 2--Identify data uses and needs
- Stage 3--Design a data collection program.

For the efficient use of resources, an RI is best approached as an iterative process. After each phase of the RI, existing data will be evaluated to assess any gaps that must be addressed in the next phase of the collection effort; the DQOs will be revised accordingly. As the overall understanding of site conditions improves and the range of potential remedial alternatives is narrowed, data gaps will decrease.

Section 4.1 summarizes Stage 1 of the process used for 100-KR-4 operable unit and states the resulting DQO.

4.1 DECISION TYPES

Stage 1 of the DQO process is undertaken to identify the decision makers and data users, and to define the types of decisions that will be made as part of the RI/FS. The major elements of Stage 1 include the following:

- Identifying and involving data users
- Evaluating available information
- Developing a conceptual model
- Specifying RI/FS objectives and decisions.

4.1.1 Data Users

Data users can be subdivided into primary and secondary categories. Primary data users are those individuals or organizations directly involved in ongoing RI/FS activities. Primary data users for the 100-KR-4 operable unit include managers from the DOE, Westinghouse Hanford, EPA, and Ecology; the DOE, EPA, and Ecology unit managers; unit manager contractor representatives; technical contributors; and decision makers.

Secondary data users are those individuals or organizations who rely mainly on output from the RI/FS studies to support their activities. Secondary data users include the DOE headquarters secretary, the EPA regional administrator, the directors of the Washington Departments of Ecology and Health, other federal and state agencies, the general public, and special interest groups.

Most data needs are defined by primary data users. Secondary data users may also provide input to the decision makers and primary data users by communicating generic or site-specific data needs or regulatory requirements, or by comment or question during the review process.

Information obtained during the RI Phase I for the 100-KR-4 operable unit will be managed in accordance with the data management plan, Attachment 4. Public participation in the RI/FS will be solicited in accordance with the community relations plan, Attachment 5. Implementation of these two plans will ensure that the data needs of both the primary and secondary data users identified for the site will be met.

4.1.2 Available Information

Additional available information will be reviewed and evaluated as the initial step in the RI/FS process. This review provides the foundation for additional onsite activities and serves as the database for potential scoping studies. Much information for this operable unit was reviewed and evaluated by the project team to determine the adequacy of existing information so that data needs could be identified. Additional data will be sought in a comprehensive review of data sources (e.g., USGS files). Information on the physical setting of the 100-KR-4 operable unit is summarized in Chapter 2.0, and the existing data that were evaluated to guide the development of the RI Phase I is presented and summarized in Chapter 3.0.

4.1.3 Conceptual Models

Conceptual models describe a site and its environments and hypotheses regarding the contaminants present, their routes of migration, and their potential impacts on sensitive receptors. The hypotheses are tested, refined, and modified throughout the RI/FS process. Based on the data reviewed by the project team, a conceptual site model was developed for the 100-KR-4 operable unit and is presented in Chapter 3.0.

4.1.4 Remedial Investigation/Feasibility Study Objectives and Decisions

In a broad sense, the objectives of a remedial action program are to determine the nature and extent of release or threat of release of hazardous substances and to select a cost-effective remedial action to minimize or eliminate that threat. Achieving these broad objectives requires that several interrelated activities be performed. Each activity must have objectives, acceptable levels of uncertainty, and attendant data quality requirements. The first step toward the development of a cost-effective data collection program is clear, precise decision statements (EPA 1987). The decision framework for developing the data collection program for the RI Phase I can be summarized in the following questions.

- Where are the contaminants located?
- What contaminants are present? -
- What are the concentrations of these contaminants in the environment?
- What is the potential for the contaminants to move within the environment?
- What are the risks to people and the environment if these contaminants are not separated from the environment?
- If the risks from the contaminants are unacceptable, then how can the risks be reduced to acceptable levels?
- If the risks can be reduced, what is the most cost-effective way to reduce the risks?

The activities that provide answers to the first four questions are classified as site-characterization activities. A baseline risk assessment is performed to determines the risks to people and the environment. The FS determines how risks can be reduced to acceptable levels, and the most cost-effective way to accomplish the task.

Existing data for the 100-KR-4 operable unit (as defined in Chapter 3.0) are insufficient to identify the contaminants present, their exact locations, their concentrations, and their potential to migrate in the environs. Therefore, RI Phase I activities are proposed in each of the media at the 100-KR-4 operable unit to answer these questions with data of appropriate quantity and quality.

Following the completion of RI Phase I data development activities, a baseline risk assessment will be performed to estimate the short-term risks to people and the environment from the contaminants that are found. The risk assessment will become one mechanism for identifying potential interim response actions that may be needed at the 100-K Area. The risk assessment will be revised and updated following Phase II data activities to estimate the long-term risks to people and the environment and identify any additional short-term risks requiring interim action.

Questions regarding acceptable levels of contaminants and cost-effective methods of reducing risks will be answered by the FS. These studies will be performed concurrently with the RI, with alternative identification and preliminary screening beginning early in the process. Alternative selection will take place once the contaminants have been identified and their locations and concentrations established.

4.2 DATA USES AND NEEDS

Stage 2 of the DQO process defines data uses and specifies the types of data needed to meet the project objectives. Although data needs are identified generally during Stage 1, specific data uses are defined in Stage 2 (EPA 1987). The major elements of DQO Stage 2 include the following:

- Identifying data uses
- Identifying data types
- Identifying data quality/quantity needs
- Evaluating sampling/analysis options
- Reviewing data quality parameters.

4.2.1 Data Uses

During the RI/FS, most data uses fall into one or more of four general categories: (1) site characterization, (2) public health evaluation and risk assessment, (3) evaluation of remedial action alternatives, and (4) worker health and safety.

Site characterization refers to the determination and evaluation of the physical and chemical properties of the waste and contaminated media present at the site, and an evaluation of the nature and extent of contamination. The site-characterization process involves the collection of necessary geologic, hydrologic, and meteorologic data as well as data on specific contaminants and sources.

Data collected to conduct a public health evaluation and risk assessment at the 100-KR-4 operable unit include input parameters for various performance assessment models, site-characteristics, and contaminant data required to evaluate the threat to public health and welfare through exposure to the various media. These needs usually overlap with site characterization needs, but higher-level quality control is often needed for risk assessment purposes and applicable or relevant and appropriate requirement (ARAR) identification.

Data collected to support evaluation of the 100-KR-4 operable unit remedial alternatives include site characteristics and engineering data required for initial screening of alternatives, feasibility-level design, and preliminary cost estimates. Once an alternative is selected for implementation, much of the data collected during the RI/FS can be used for the final engineering design. Generally, collection of information during the

RI for use in the final design is not cost effective. It is usually more cost effective to gather such specific information during a predesign investigation.

The worker health and safety category includes data collected to establish the level of protection for workers during various RI activities. These data are used to determine levels of concern for the personnel working in the vicinity of the 100-KR-4 operable unit.

4.2.2 Data Types

The data use categories described in Section 4.2.1 define the general purpose and intent for collecting additional data. Based on the intended uses, a concise statement regarding the data types needed can be developed. The data types specified at this stage should not be limited to chemical parameters, but should also include necessary physical parameters such as bulk density and viscosity. Because environmental media and source materials are interrelated, data types used to evaluate one medium may also be useful to characterize another medium. By identifying data types by medium, overlapping data needs are identified. The data objectives, needs, and types to be collected for the RI Phase I are identified in Table 4-1.

4.2.3 Data Quality Needs

The various tasks and phases of a RI may require different levels of data quality. Important factors in defining data quality include selecting appropriate analytical levels and validation and identifying contaminant levels of concern as described in the following sections. The EPA document, *Data Quality Objectives for Remedial Response Activities* (EPA 1987) and the Westinghouse Hanford document, *A Proposed Data Quality Strategy for Hanford Site Characterization* (McCain and Johnson 1990) will be used to help define these levels.

4.2.3.1 Analytical Levels and Validation. In general, increasing accuracy and precision are obtained with increasing cost and time; therefore, the analytical level used to obtain data should be commensurate with the intended use. Table 4-2 defines five analytical levels based on overall data quality. Individual DQOs and the appropriate analytical levels associated with each data need are given in Table 4-3.

Before laboratory and field data can be used in the RI/FS process, they must first be validated, which involves determining the usability and quality of the data. Once the data are validated, they can be used to successfully complete the RI/FS process. The activities involved in the data validation process include the following:

- Confirm that the laboratory data meet the QA/QC criteria
- Confirm the usability and quality of field data, which includes geological logs, hydrologic data, and geophysical surveys
- Document and manage information properly so it is usable.

To address the first objective, all laboratory data must meet the requirements of the specific QA/QC parameters as set up in the QAPP (Part 2 of Attachment 1) before it can be considered usable. The QA/QC parameters include laboratory precision and accuracy, method blanks, field blanks, instrument calibration, and holding times.

The usability of field data must also be assessed by a trained and qualified person. The project hydrologist will review the geologic logs, hydrologic data, and geophysical surveys on a daily basis, and senior technical reviews will be conducted periodically throughout the project.

Consistent data management procedures are also necessary for validated data. Data management includes proper field activities, sample management and tracking, and document control and inventory. Specific procedures are discussed in the Data Management Plan (Attachment 4).

4.2.3.2 Contaminant Levels of Concern. To identify appropriate data needs, contaminant levels of concern and action-specific requirements must be identified. This is accomplished by identifying preliminary ARARs. Because of the iterative nature of the RI/FS process, ARAR identification continues throughout the RI/FS as a better understanding is gained of site conditions, site contaminants, and remedial action alternatives.

There are three categories of ARARs: (1) chemical-specific ARARs define acceptable exposure levels and are used to establish preliminary remedial action objectives, (2) action-specific ARARs are requirements governing the implementation of remedial actions at the site, and (3) location-specific ARARs are requirements that set restrictions on activities conducted within specific locations, such as areas identified as having historical or archeological significance. The preliminary federal and state ARARs identified for the 100-KR-4 operable unit are discussed in Section 3.2.

During RI/FS planning, chemical- and location-specific ARARs are identified to develop cleanup objectives and focus data collection. Chemical-specific ARARs are expressed as numerical values and are derived from specific standards (i.e., maximum contaminant levels [MCLs] as specified in the Safe Drinking Water Act) or are health-based (i.e., levels of contaminants that pose an excess lifetime cancer risk of 1×10^{-4} to 10^{-6}). By identifying these standards now, appropriate analytical methods and detection limits can be selected for the contaminants of concern. Analytical methods chosen will need to have detection limits below the identified level of concern. The analytical methods proposed in Table 4-3 were selected based on the chemical-specific requirements identified in the preliminary ARARs analysis.

The location-specific ARARs that must be considered before implementation of any field activities are discussed in Section 3.2.3 and identified in Table 3-33. The existence and potential value of any archeological resources or critical habitats need to be determined before any field investigation activities are undertaken. To ensure that any archaeological resources are not impacted during the RI/FS process, various Indian tribes will be afforded the opportunity to review and comment on the 100-KR-4 operable unit work plan before sampling.

4.2.4 Data Quantity Needs

The number of samples that need to be collected during an RI/FS can be determined by using several approaches. In instances where data are lacking or are limited, a phased sampling approach may be useful. In the absence of available data, an approach or rationale will need to be developed to justify the sampling locations and the numbers of samples selected. In situations where data are available, statistical techniques may be useful in determining the number of additional data required.

4.2.5 Sampling and Analyses Options

The resources available for performing a RI need to be evaluated during RI/FS planning. Data collection activities can then be structured to obtain the needed data in a cost-effective manner. Developing a sampling and analysis approach that ensures that appropriate levels of data quality and quantity are obtained with the resources available may be accomplished by using a phased RI approach and field screening techniques.

The RI/FS for the 100-KR-4 operable unit will take advantage of both approaches. Scoping studies conducted either before or in conjunction with the RI Phase I activities, followed by a more detailed RI Phase II, will provide for a comprehensive characterization of the site in a cost-effective manner.

Another important aspect of planning the data collection program is determining the quantity of high-level analytical data required to support RI/FS objectives. To obtain needed data in a cost-effective manner, and still support RI/FS objectives, a combination of lower-level analytical data (Levels I, II, and III) and higher-level analytical data (Levels IV and V) will be collected. To provide litigation quality data, for instance, the samples collected from the sources will be analyzed by CLP procedures. This will provide the certainty necessary to determine the contaminants present in the source material. Samples collected from the remaining media (i.e., soils, ground water, surface water, sediments) will be analyzed by either SW 846 or CLP procedures. Approximately 80% of the samples collected for nonradioactive analyses will be Level III data and 20% will be Level IV. All samples for radioactive nuclides will Level V data. All data will be validated to qualify the accuracy and usefulness of the results regardless of the analytical method used (EPA 1986).

4.2.6 The Precision, Accuracy, Representativeness, Completeness, and Comparability Parameters

The precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters are indicators of data quality. Ideally, the end use of the data collected should define the necessary PARCC parameters. Once the PARCC requirements have been identified, before data collection, appropriate analytical methods can be chosen to meet established goals and requirements. A complete discussion of the PARCC requirements for the RI Phase I are discussed in the QAPP.

4.3 DATA COLLECTION PROGRAM

Conducting an RI in phases is a common method for optimizing the quantity and quality of the data collected. It would be very inefficient and overly expensive to specify beforehand all the types of samples and analyses that will yield the most complete and accurate understanding of the contamination and physical behavior of the site. Data adequate to achieve RI/FS goals and objectives are obtained at a lower cost by using the information obtained in each step to focus the investigation in succeeding steps. Phased RIs are encouraged by EPA's current RI/FS guidance document (EPA 1988a).

The first phase of the RI Phase I of the 100-KR-4 operable unit will complete the gathering and analysis of existing information and collect new data believed necessary to confirm and refine the conceptual model. Subsequent phases may be needed to further reduce uncertainty, fill in remaining gaps in the data, collect more detailed information for certain points where such information is required, and conduct any needed treatability studies. The need for subsequent investigation phases will be assessed early in the RI Phase I investigation and as data become available.

4.3.1 General Rationale

The general rationale for undertaking an RI of the 100-KR-4 operable unit is to develop needed data that is lacking in the available information. The amount of information that has been assembled and evaluated to date is considerable. Because of the size of the operable unit, the complexity of past operations, and the number of waste management units, the amount of information that ultimately will be required is much greater than what is already available.

The following general rationale and corresponding technical work plan approach or strategy will be used to collect additional data for the 100-KR-4 operable unit:

- Existing data will be used to the maximum extent possible. Although existing data may not be validated to current standards, the data are still useful in developing the site model and helping to focus and guide the investigations.

- Additional data and high-quality data will be collected to obtain the maximum amount of useful information for the amount of time and resources invested in the investigation.

- Data will be collected, as needed, to support the intended data uses identified in Section 4.2.1.

- Nonintrusive sampling (e.g., geophysical testing, surficial soil and source sampling, sampling of existing ground water monitoring wells) will be conducted early in the RI Phase I, or in a separate pre-RI process to identify necessary interim response actions. The information obtained from an early study will be evaluated and used to revise the scope of the RI/FS.

- Phase I data will be collected to confirm and refine the conceptual model, refine the analyte list for any subsequent investigations, and provide the information to conduct a short-term (i.e., before implementation of site cleanup activities) risk assessment. If the short-term risk assessment indicates a potential risk at the site greater than 1×10^{-4} (1 in 10,000 chances of developing cancer), interim response actions will be taken.

- The RI Phase II for the 100-KR-1 and 100-KR-4 operable units will support the long-term risk assessment for final cleanup actions. If the long-term risk assessment indicates a potential risk greater than 1×10^{-4} to 1×10^{-6}, remedial action alternatives will be developed and evaluated to address these risks.

- The investigations for the 100-KR-1 and 100-KR-4 operable units will be coordinated to reduce overall costs and maximize the usefulness of the data obtained.

- Field investigation techniques will be used to minimize the amount of hazardous waste generated; however, any waste generated will be containerized in accordance with EII 4.2, Interim Control of Unknown Suspected Hazardous and Mixed Waste (WHC 1989c).

4.3.2 General Strategy

As stated earlier, one objective of the RI/FS is to gather additional information sufficient to support an RI/FS. The general approach or strategy for obtaining the additional information is presented.

The following strategies will be used to collect additional data for the 100-KR-4 operable unit:

- All proposed ground water investigations will be conducted as part of the 100-KR-4 operable unit work plan.

- Well locations will be coordinated with surrounding operable units and potential sources so that, where possible, one well may serve multiple purposes.

- Sampling parameter selection will be based on verifying overall conditions and then narrowed to contaminants of concern. Periodic overall sampling will verify that there are no new contaminants.

- River bank springs and soils, vadose zone, and sediment and aquatic biota investigations will be coordinated with ground water investigations to provide information on contaminant movement and fate. These investigations will be conducted as part of the 100-KR-4 work plan.

- All the results from various existing onsite ground water sampling activities will be compiled regularly to avoid duplication of effort and provide one complete database for the 100-KR-4 operable unit.

This should continue during any long-term site monitoring as well as during implementation of this work plan.

- The locations and types of sources that exist in the 100-KR-1, 100-KR-2, and 100-KR-3 operable units will also be identified and evaluated as a possible contributor to vadose zone and ground water contamination in the 100-KR-4 operable unit work plan. Collection of data in the three operable units will be directed toward ground water information. However, these data will be collected in such a manner that they can be used in the specific work plans for the 100-KR-2 and 100-KR-3 operable unit work plans when they are developed.

The following strategies also will be used to collect additional data for the 100-KR-4 operable unit by coordinating the 100-KR-1 and 100-KR-4 operable unit investigations and using data from the 100-KR-2 and 100-KR-3 operable units:

- The 100-KR-4 operable unit ground water investigation will begin at the same time as the 100-KR-1 operable unit investigation. By designing the two investigations in an integrated manner, the costs of the information obtained will be reduced, and the value of the information will be increased. For example, by locating deeper boreholes and wells needed for the ground water investigation in areas adjacent to the disposal units, where near-surface samples are needed for the source investigation, the overall costs of the drilling and sampling will be reduced.

- All similar field work for the 100-KR-4 and 100-KR-1 operable units will, to the maximum extent possible, be conducted at the same time. These and other means will be used to reduce costs or improve the value of the information obtained by coordinating the two investigations.

- The locations and types of sources that exist in the 100-KR-1 operable unit will be identified and evaluated as a possible contributor to vadose zone and ground water contamination. Discussions concerning the sources in the 100-KR-1 operable unit are included in the 100-KR-1 operable unit work plan.

4.3.3 Investigation Methodology

The initial phase of the RI will include the following integrated investigational tasks:

- Source investigation
- Geological investigation
- Surface water and sediment investigation
- Vadose zone investigation
- Ground water investigation

- Air investigation
- Ecological investigation
- Other investigations (cultural, topography).

4.3.3.1 Source Investigation. The purpose of the source investigation for the 100-KR-4 operable unit is to identify the locations and type of sources that exist in the 100-KR-1, 100-KR-2, and 100-KR-3 operable units that may contribute to ground water contamination in the 100-KR-4 operable unit. Another concern is that cross contamination may result in the course of the ground water investigation from drilling through highly contaminated materials in one of the source operable units. This will be avoided by (1) generally locating monitoring wells where vadose zone contamination is expected to be low, (2) using staged well construction, and (3) collecting samples of the materials in the vadose zone as wells are being drilled to confirm levels of contamination. Activities to be performed during the source investigation include the following:

- Compile and review data to evaluate liquid disposal sites for the potential for significant releases to the ground water; potentially significant sources not currently identified in this work plan may be considered based on the results of this evaluation.
- Conduct an area walkover of the 100-K Area to identify and locate additional sources, and provide for a better understanding of the site.
- A topographic base map that will serve as a reference base for all of the RI will be developed.

4.3.3.2 Geologic Investigation. A geologic investigation for the 100-KR-4 operable unit will be performed to obtain the geometry of the vadose zone and ground water system and the nature of unsaturated and saturated sediments that make up this system. The geologic investigation will include the following tasks.

- Compilation and review of existing data to further the understanding of the geologic conditions at the 100-K Area.
- An area walkover to develop a preliminary site-wide geologic map of the surficial sediments, evaluate access for drilling equipment, and locate surface utilities.
- Evaluation of geologic data collected during the field mapping and during the ground water investigation (e.g., geologic and geophysical logs).

4.3.3.3 Surface Water and Sediment Investigation. A surface water and sediment investigation will be conducted to evaluate the impact of facility operations on the exposed shoreline and the quality of the Columbia River. The investigation will include the following:

- Compilation and review of existing data to further the understanding of the connection of the ground water and surface water systems
- Mapping, sampling, and analysis of river bank springs (seepage measurements will also be conducted)
- Monitoring the river stage of the Columbia River at the 100-K Area
- Evaluation of the surface water data.

4.3.3.4 Vadose Zone Investigation. The purposes of the vadose zone investigation in the 100-KR-4 Phase I RI for the operable unit are to provide information on soil chemistry and physical properties as they relate to potential impacts on ground water (e.g., recharge potential) and to provide supporting information for the 100-KR-1, -2, and -3 source operable unit RIs. Soil samples for analysis will be collected from the vadose zone in conjunction with the monitoring well installation.

4.3.3.5 Ground Water Investigation. The purpose of the ground water investigation is to determine the nature, extent, and movement of ground water contamination in the hydrostratigraphic units underlying the 100-K Area. The investigation will include the following:

- Compilation of existing data to further understand the ground water system in the 100-K Area
- Installation of monitoring wells at selected locations and in selected hydrostratigraphic units (these and certain existing wells will provide access for geologic and geophysical logging, hydraulic testing, hydraulic head measurement, and ground water sampling for chemical and radionuclide analysis)
- Sampling of borehole (for well installation) soils and sediments for soil physical and soil chemical analyses
- Evaluation of data collected during this investigation to define the hydrologic and water quality conditions of the ground water system in the 100-K Area.

4.3.3.6 Air Investigation. The 100-KR-4 operable unit air investigation will consist of onsite particulate sampling and monitoring of both volatile organic compounds and radiation levels as part of the health and safety program.

4.3.3.7 Ecological Investigation. The ecological investigation for the 100-KR-4 operable unit will consist of a review of biological data developed and evaluated at other areas on the Hanford Site, supplemented by a focused, onsite riparian zone, and aquatic biological survey. The objectives of this survey will be restricted to determining whether any critical habitat exists within the 100-KR-4 operable unit, refining the contaminant pathways model, and obtaining contaminant concentration data to quantify the transfer functions.

4.3.3.8 Cultural Resource. The cultural resource investigation will involve verifying the locations of known archaeological sites in the 100-K Area by reviewing data and conducting a field survey. The focus of the investigation will be to determine whether archaeological resources are present at proposed drilling sites.

4.3.4 Data Evaluation and Decision Making

During the RI Phase I for the 100-KR-4 operable unit, data will be evaluated as soon as they become available, for use in restructuring and focusing the RI/FS, as appropriate. Data reports that summarize and interpret the collected data will be developed. The data can then be used to refine the conceptual model, further assess potential contaminant-specific ARARs, develop the baseline risk assessment, begin development of the FS, and complete the RI report.

The objectives of data evaluation are as follows:

- Reduce and integrate the data so that data gaps can be identified and the goals and objectives can be met for the various RI/FS objectives
- Confirm that the data are representative of the media sampled and that QA/QC criteria have been met.

The decisions to be made upon the completion of the 100-KR-4 operable unit RI Phase I will primarily be to identify the need for additional data collection. Figures 4-1 and 4-2 illustrate the decision-making process that will be used during the RI Phase I for sources, soils, surface water and sediments, ground water, air, and biota.

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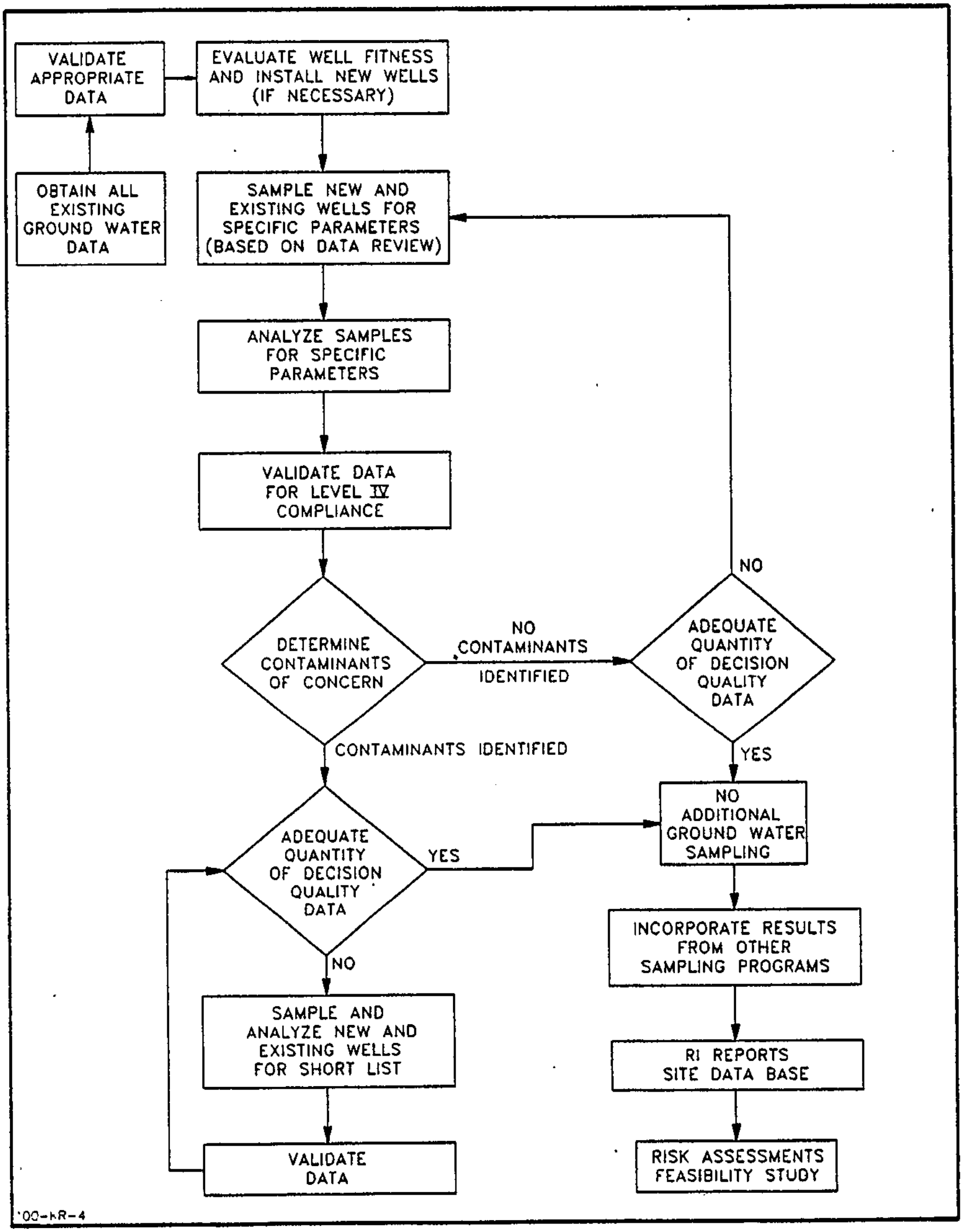

Figure 4-1. Decision Tree For RI/FS Ground Water Sampling.

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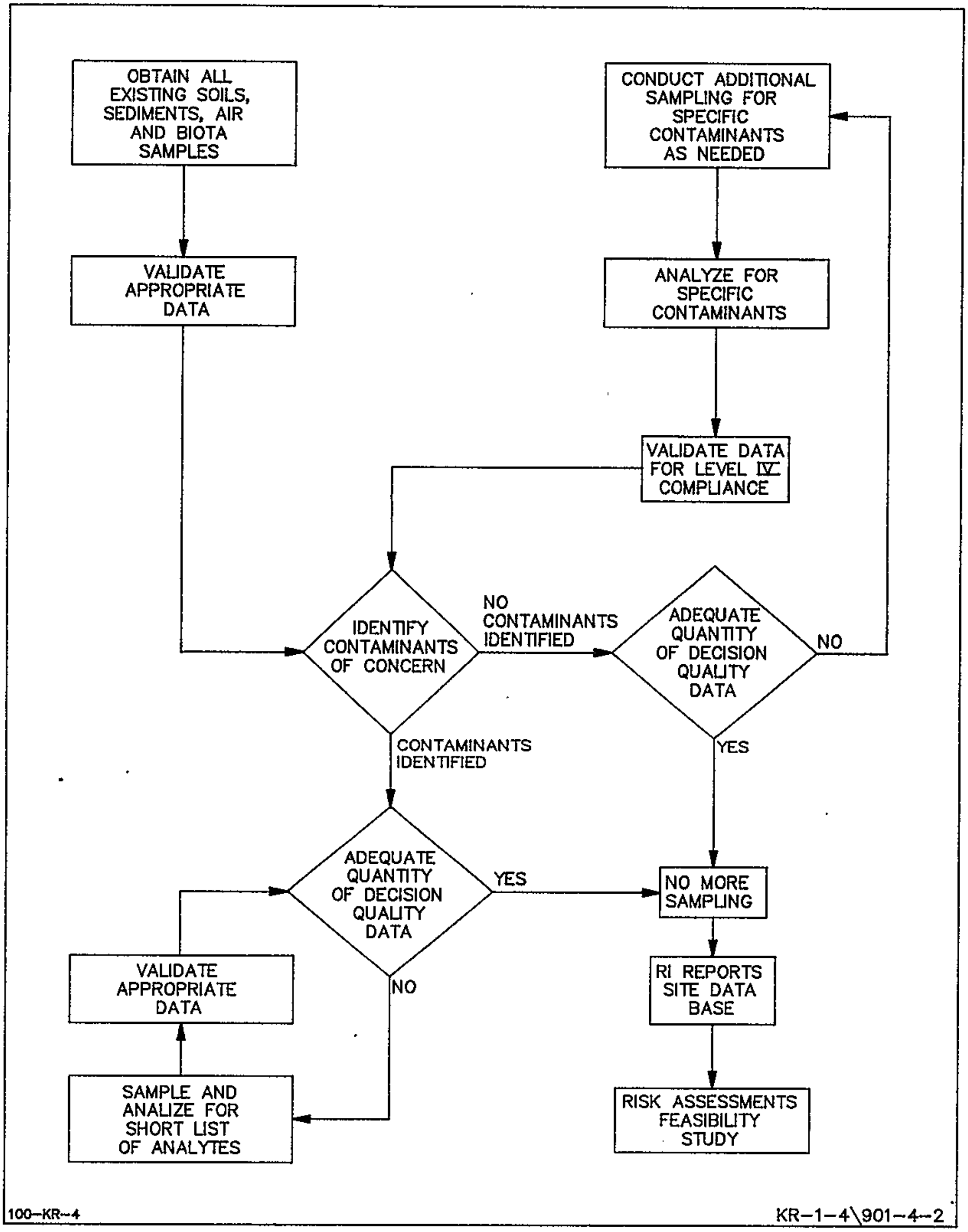

Figure 4-2. Decision Making Tree for RI/FS Soil, Sediment, Air, and Biota Sampling.

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Table 4-1. Data Objectives for the 100-KR-4 Work Plan.
(sheet 1 of 2)

Data objectives	Data needs	Data types
Source:		
Refine understanding of facility characteristics	Locations of contaminant sources	-Site walkover -Source data compilation
Determine waste characteristics and spatial distribution of contaminants	Chemical and radiological characterization of the sources	-Chemical and radiological properties -Soil gas survey
Topography	Topographic base map development	-Ground elevations -Facility locations
Geological:		
Identify pathways for contaminant migration	Stratigraphy, structure	-Lithology -Soil/sediment type
Determine potential migration rates, direction and dispersion of contaminants	Properties of the vadose zone	-Physical properties -Geotechnical properties
Surface Water/Sediment:		
Determine presence or absence of contaminants	Characterization of the water quality and sediments	-Field parameters (water quality) -Chemical and radiological properties
Vadose Zone:		
Determine presence or absence and spatial distribution of contaminants	Contaminant characterization of the soil column	-Chemical and radiological properties
Refine concepts of unsaturated flow and recharge	Soil physical properties	-Physical properties
Ground Water:		
Refine hydrostratigraphic conceptual model	Geologic model; Properties of lithologic units; Occurrence of ground water; Ground water discharge areas; Ground water recharge sources	-Site lithology -Hydraulic properties -Ground water elevation -Hydraulic gradient between aquifers -Interaction with Columbia River
Define nature and extent of contaminants	Interaction between vadose and saturated soils; Occurrence of contaminants; Concentration of contaminants; Variations of ground water; quality relative to source areas, spatial and temporal	-Porosity -Chemical analysis of ground water
Air:		
Determine presence or absence of contaminants around field activities	Air quality	-Physical properties -Chemical and radiological properties

Table 4-1. Data Collection Objectives for the 100-KR-4 Operable Unit.
(sheet 2 of 2)

Data objectives	Data needs	Data types
Ecological:		
Determine aquatic ecosystem; Determine presence or absence of contaminants	Determine existence of critical habitats; Concentration of contaminants; Identify ecological processes	-Literature review -Aquatic biota survey
Cultural Resource:		
Determine presence or absence of archaeological or historical sites eligible for National Register of Historic Places		-Literature review -Field survey

Table 4-2. Analytical Levels for the 100-KR-4 Operable Unit Work Plan.

LEVEL I	Field screening--This level is characterized by the use of portable instruments that can provide real-time data to assist in the optimization of sampling point locations and for health and safety support. Data can be generated regarding the presence or absence of certain contaminants (especially volatiles) at sampling locations.
LEVEL II	Field analysis--This level is characterized by the use of portable analytical instruments that can be used onsite, or in mobile laboratories stationed near a site (close-support laboratories). Depending on the types of contaminants, sample matrix, and personnel skills, qualitative and quantitative data can be obtained.
LEVEL III	Laboratory analysis using methods other than the contract laboratory program (CLP) routine analytical services (RAS)--This level is used primarily in support of engineering studies using standard EPA-approved procedures. Some procedures may be equivalent to CLP RAS without the CLP requirements for documentation.
LEVEL IV	CLP RAS--This level is characterized by rigorous QA/QC protocols and documentation and provides qualitative and quantitative analytical data. Some regions have obtained similar support using their own regional laboratories, university laboratories, or other commercial laboratories.
LEVEL V	Nonstandard methods--Analyses that may require method modification or development are considered Level V by CLP special analytical services.

Per McCain and Johnson (1990), Levels I, II and III are equivalent to field or laboratory screening and Levels IV and V are equivalent to validated laboratory analyses.

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Table 4-3. Data Types, Measurements, and Required Analytical Levels for the 100-KR-4 Operable Unit.
(sheet 1 of 3)

Data types	Measurements	Analytical method[a]	Required analytical level*	Data use[b]
Sources:				
Personal interviews	N/A	N/A	N/A	SC, WS
Site walkover	N/A	N/A	N/A	SC, EA, ED
Data compilation	Literature review	N/A	N/A	SC, EA, ED
Geologic:				
Lithology	Geologic log	SOP	I	SC, EA, ED
Soil/sediment type	Soil/sediment classification	SOP	I	SC, EA, ED
Physical properties	Porosity	ASTM	III	SC, EA, ED
	Bulk density	ASTM	III	SC, EA, ED
	Particle size distribution	ASTM	III	SC, EA, ED
	Moisture content	ASTM	III	SC, EA, ED
	Permeability	ASTM	III	SC, EA, ED
Geochemical properties	Cation exchange capacity	MOSA	III	SC, EA, ED
	Total organic carbon	MOSA	III	SC, EA, ED
	pH	SOP	III	SC, EA, ED
Surface Water:				
Field parameters	pH	SOP	I	SC, EA, ED
	Temperature	SOP	I	SC, EA, ED
	Total suspended solids	SOP	I	SC, EA, ED
	Specific conductance	SOP		SC, EA, ED
	Dissolved oxygen	SOP		SC, EA, ED
	Oxidation reduction potential	SOP		SC, EA, ED
Chemical properties	Radionuclides	SOP/LAP	III, V	SC, EA, ED, RA
	Organics	80% SW846/20% CLP	III, IV	SC, EA, ED, RA
	Inorganics	80% SW846/20% CLP	III, IV	SC, EA, ED, RA
Physical properties	Seepage	SOP	I	SC, EA, ED, RA
Ground water interaction with Columbia River	River elevation change	SOP	I	SC, EA, ED, RA
Chemical properties	Radionuclides	SOP/LAP	III, V	SC, EA, ED, RA
	Organics	80% SW846/20% CLP	III, IV	SC, EA, ED, RA
	Inorganics	80% SW846/20% CLP	III, IV	SC, EA, ED, RA

Table 4-3. Data Collection Types, Measurements, and Required Analytical Levels for 100-KR-4 Operable Unit.
(sheet 2 of 3)

Data types	Measurements	Analytical method[a]	Required analytical level*	Data use[b]
Vadose:				
Chemical properties	Radionuclides	SOP/LAP	III/V	SC, EA, ED, RA
	Organics	80% SW846/20% CLP	III/IV	SC, EA, ED, RA, AA, WS
	Inorganics	80% SW846/20% CLP	III/IV	SC, EA, ED, RA, AA, WS
	Herbicides/pesticides	80% SW846/20% CLP	III/IV	SC, EA, ED, RA, AA, WS
	PCBs	80% SW846/20% CLP	III/IV	SC, EA, ED, RA, AA, WS
Ground Water:				
Lithology	Geology of well location	SOP	I	SC, EA, ED, RA
Hydrologic properties	Field test wells	SOP	II	SC, EA, ED, RA
	Lab test soil samples	SOP	III	SC, EA, ED, RA
Ground water elevation	Well cadastral survey	SOP	I	SC, EA, ED, RA
	Depth to ground water	SOP	I	SC, EA, ED, RA
	Hydraulic gradient between aquifers	N/A	I	SC, EA, ED, RA
Ground water chemistry	Radionuclides	SOP/LAP	III/V	SC, EA, ED, RA
	Organics	80% SW846/20% CLP	III/IV	SC, EA, ED, RA, AA, WS
	Inorganics	80% SW846/20% CLP	III/IV	SC, EA, ED, RA, AA, WS
	Herbicides/pesticides	80% SW846/20% CLP	III/IV	SC, EA, ED, RA, AA, WS
	PCBs	80% SW846/20% CLP	III/IV	SC, EA, ED, RA, AA, WS
Aquatic Biota:				
Literature review	Algae and other low-level tropic biota	N/A	I	SC, EA, ED, AA
	Biota uptake of radionuclides and inorganics	N/A	I	SC, EA, ED, AA
	Presence of critical habitats	N/A	I	AA

Table 4-3. Data Collection Types, Measurements and Required Analytical Levels for the 100-KR-4 Operable Unit.
(sheet 3 of 3)

Date types	Measurements	Analytical method	Required analytical level	Data use
Cultural Resource:				
Literature search	Location of surficial archaeological sites	N/A	N/A	AA
	Presence of historic or archaeological sites that my be eligible for the National Register of Historic Places	N/A	N/A	AA
Topographic mapping	1 1/2 ft contours (0.5-m)	SOP	I	SC, EA, ED

SOP = Standard operating procedures (i.e., company or site-specific)
CLP = Contract laboratory program (i.e., laboratory specific or Level V)
LAP = Laboratory analytical protocol
N/A = Not applicable
ASTM = American Society of Testing and Materials
SC = Site characterization
EA = Evaluation of alternatives
ED = Engineering design
RA = Risk assessment
WS = Worker safety
AA = Address ARARs
SW846 = EPA 1986.

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5.0 REMEDIAL INVESTIGATION/FEASIBILITY STUDY TASKS

This section describes the various tasks to be implemented during the course of the project. The specified tasks are designed to provide information to meet the DQOs identified in Chapter 4.0.

5.1 OPERABLE UNIT CHARACTERIZATION

Chapters 2.0 and 3.0 provided discussions about the current knowledge of the environmental characteristics and distributions of contaminants in the 100-KR-4 operable unit. These discussions provided the basis for identifying additional data needed to evaluate hazards associated with the 100-KR-4 operable unit and to design and implement remedial actions. Chapter 4.0 presented these needs in the form of 12 specific tasks. These tasks are discussed individually in this section. The data needed, techniques for collecting the data, and data uses are also presented.

Several pre-RI nonintrusive characterization activities are recommended to be conducted during the review period of this work plan. These activities would be conducted to: (1) identify areas posing immediate and ongoing risks to human health or the environment, and (2) to refine the scope of the RI investigation. Examples of pre-RI activities might include sampling and analysis of existing wells or water level measurements of existing wells.

5.1.1 Task 1--Project Management

The objectives of project management during the performance of the 100-KR-4 operable unit RI/FS are to direct and document project activities to ensure that data and evaluations generated meet the goals and objectives of the 100-KR-4 operable unit work plan, and to administer the project within budget and schedule. The initial project management activity will be to assign individuals to roles established in the PMP (Attachment 3). Specific activities that will occur throughout the RI/FS include the following:

- General management
- Meetings
- Cost control
- Schedule control
- Data management
- Progress reports.

5.1.1.1 General Management. General management includes the day-to-day supervision of, and communication with, project staff and subcontractors. Throughout the project, daily communications between office and field personnel will be maintained, along with periodic communications with subcontractors. This constant and continual exchange of information will be necessary to assess progress, to identify potential problems quickly enough to make necessary corrections, and to keep the project focused on the objectives, the schedule, and to stay within the budget.

5.1.1.2 Meetings. Meetings will be held, as necessary, with members of the project staff, subcontractors, regulatory agencies, and other appropriate entities to communicate information, assess project status, and resolve problems.

A kickoff meeting will be held with designated project personnel and project staff meetings should be held weekly. The 100-KR-4 operable unit project coordinators for this and other operable units will meet on a weekly basis to share information and to discuss progress and problems. The frequency of other meetings will be determined based on need and on schedules in the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989).

5.1.1.3 Cost and Schedule Control. Project costs, including labor, other direct costs, and subcontractor expenses, will be tracked monthly. The budget for tracking activities will be computerized and will provide the basis for invoice preparation and review and for preparation of progress reports. Scheduled milestones will be tracked monthly for each task of each project phase. This will be done in conjunction with cost tracking.

5.1.1.4 Data Management. The project file for the 100-KR-4 operable unit will be organized, secured, and accessible to project personnel. All field reports, field logs, health and safety documents, QA/QC documents, laboratory data, memoranda, correspondence, and reports will be logged into the file upon receipt or transmittal. This task is also the mechanism for ensuring that data management procedures documented in the DMP (Attachment 4) are carried out.

5.1.1.5 Progress Reports. Quarterly progress reports will be prepared, distributed to project personnel and entities (project and unit managers, coordinators, contractors, subcontractors, etc.), and entered into the 100-KR-4 operable unit project file. The reports will summarize the work completed, present data generated, and provide evaluations of the data as they become available. Progress, anticipated problems and recommended solutions, upcoming activities, key personnel changes, status of deliverables, and budget and schedule information will be included.

5.1.2 Task 2--Source Investigation

The purpose of the source investigation in the 100-KR-4 operable unit Phase I RI is to: (1) identify sources that may contribute ground water contamination, and (2) reduce the potential of cross-contamination that would occur if a highly concentrated source were penetrated during the drilling and well installation stage of the ground water investigation. The source investigation for 100-KR-1 operable unit will provide the information for that operable unit. The source investigation for the 100-KR-4 operable unit will be limited to the four subtasks listed below:

- Subtask 2a--Data compilation and review
- Subtask 2b--Topographic base map development
- Subtask 2c--Field activities
- Subtask 2d--Source unit screening.

A detailed source investigation using more refined survey methods may be performed as part of the RI for each of the other operable units.

5.1.2.1 Subtask 2a--Data Compilation and Review. The source data compilation will consist of gathering information on the location, types, and quantities of wastes disposed of in operable units 100-KR-1, -2, and -3. The objectives for this subtask include the following:

- Evaluate disposal sites for potentially significant releases to ground water; potentially significant sources, not currently identified in this work plan, may be considered for further investigation based on the results of this evaluation
- Provide facility and disposal information to support the overall RI/FS.

This subtask will include a literature review and interviews with pertinent Hanford Site personnel. Additional information may be obtained during other tasks such as the site walkover survey, and source sampling (100-KR-1 operable unit).

5.1.2.2 Subtask 2b--Topographic Base Map Development. A topographic base map will be prepared to show the project site. Facilities and waste unit sources will be included, corrected, and supplemented as appropriate, based on an inspection of aerial photographs and field surveys of the 100-K Area. The base map will be developed as part of the planned activities of the 100-KR-4 operable unit RI. A Hanford Site-wide base map is currently under development and will be used if available. Contour intervals will be at 1.5 ft (0.5 m) and at a 1:2,000 scale. For the purposes of geologic mapping this map will be enlarged to a scale of 1:500.

5.1.2.3 Subtask 2c--Field Activities. A walkover of the 100-K Area will be performed primarily to verify the location and condition of source facilities shown on the site map. Discrepancies between locations indicated on the map and those observed in the field will be resolved. The presence of utilities, structures (e.g., fencing), surface features (e.g., berms), radiation zones, and markers that could affect the movement of equipment or activities of field personnel will be noted. Also, the general quality of the terrain will be surveyed to the extent that it will affect ground water monitoring well installation and river shore surveying.

5.1.2.4 Subtask 2d--Source Unit Screening. Another focus of the 100-KR-4 operable unit work plan is to screen all waste sites within the aggregate area to determine if: (1) the existing priority for that waste site should be revised and if that site should be investigated earlier than planned, (2) the site should be considered for an interim measures action, or (3) the site should be considered for imminent and substantial endangerment action.

The screening will be based on the information generated during subtask 2a. If, as a result of the screening process, any of the above actions are warranted, the 100-KR-4 operable unit work plan will be updated to reflect the actions. The screening process will be consistent with the regulatory guidance given in EPA (1988b), the proposed RCRA regulations of 40 CFR 264, and the CERCLA regulations of 40 CFR 300.410.

5.1.3 Task 3--Geologic Investigation

The overall objectives of the geologic investigation are to obtain information concerning the geometry of the vadose zone and ground water systems and determine the characteristics of the unsaturated and saturated sediments of these systems. The horizontal and vertical variations in geologic materials directly affect the movement and distribution of water and contaminants in these systems. The geologic investigation is integrated with the vadose zone and ground water investigations by using the monitoring well boreholes for multiple purposes. The proposed well locations are shown on Figure 5-1. Geologic data from the 100-KR-1 operable unit geologic investigation will be integrated with data collected in this task.

The specific objectives of the geology investigation outlined in the following sections are based on the current understanding of the site geology. As the geologic model is refined during implementation of the work plan, these objectives may need to be refined. The objectives include the following:

- Characterize the 'natural' surficial sediments and 'fill' in the 100-K Area, including shoreline sediments
- Identify and measure the elevation of the Hanford and Ringold formations contact; this contact is expected to be within the vadose zone
- Determine the lithology and geometry of strata within the Ringold Formation. Lithologic and geometric features of particular interest include cemented gravels in the upper Ringold sequence, the first clay layer below the cemented gravels in the middle Ringold sequence, the 'blue clay' in the lower portion of the middle Ringold sequence, and the sand and gravels of the lower Ringold sequence.

To accomplish the objectives, the Phase I geologic investigation has been organized into the following four subtasks:

- Subtask 3a--Data compilation and review
- Subtask 3b--Field activities
- Subtask 3c--Laboratory analysis
- Subtask 3d--Data evaluation.

5.1.3.1 Subtask 3a--Data Compilation and Review. The purpose of this task is to gain an understanding of the geology at the 100-K Area as defined by existing data. A preliminary data review was conducted in preparation of this work plan. These data will be supplemented with site-specific information not reviewed during the preliminary study; information collected during nonintrusive activities (e.g., pre-RI water level measurements); and information from relevant studies in the vicinity of the 100-K Area (e.g., the 116-6A in situ vitrification project, and RI and/or RFI studies in 100-B/C, 100-D, 100-F, 100-H, 100-N Areas).

5.1.3.2 Subtask 3b--Field Investigations. The Phase I geologic investigation includes one field activity (geologic mapping). Site geologic mapping will be conducted at a scale of approximately 1 to 500 using a base map enlarged from the topographic map prepared under Task 2. Special emphasis will be placed on differentiating between fill and 'natural' material and between types of fill and on describing conditions along the shoreline, especially near the seeps. Stereo photographs and other remote sensing techniques will be used during this activity.

5.1.3.3 Subtask 3c--Laboratory Analysis. Laboratory analysis of the physical properties of the surface and subsurface materials is discussed in Subtask 6c, because these samples will be collected from the monitoring well boreholes.

5.1.3.4 Subtask 3d--Data Evaluation. Geologic data collected during the field mapping and during the ground water investigation (e.g., geologic and geophysical logs) will be compiled and integrated with data from the 100-KR-1 operable unit vadose investigation. These data will be reviewed in order to produce a variety of graphical interpretations. The purpose of these interpretations is to illustrate subsurface geologic conditions and help illustrate their impact on ground water and contaminant movement. The graphical interpretations will include, at a minimum a site geologic map, lithologic descriptions, and stratigraphic delineations related to both elevation and depth below surface. Other graphical interpretations may be prepared including cross-sections and/or fence diagrams, contour maps of the elevation of specific geologic or hydrostratigraphic horizons, and isopach maps of specific geologic or hydrostratigraphic units.

5.1.4 Task 4--Surface Water and Sediment Investigation

The objective of Task 4 is to evaluate the impact of 100-K Area facilities on the shoreline of the Columbia River in the area, and on river water quality. The investigation will compile and interpret existing data on sediment and water quality in the area; collect new data to fill in gaps; and interpret the results of the field program relative to a risk assessment and selection of appropriate remedial actions if required.

The investigation is designed to obtain field data that will reveal whether or not residual contamination from past operations in the 100-K Area is detectable in: (1) ground water seepage from the riverbanks; (2) sediments along the river shoreline; and (3) river water adjacent to any seeps that show elevated levels of 100-K Area contamination indicators. Sampling in these three environments will have the greatest probability of identifying contamination zones attributable to 100-K Area, or preferred pathways for ground water discharge to the Columbia River. However, quantitative data from this sampling may not provide conservative estimates of total discharge into the Columbia River from ground water, because dilution by river water takes place at the interface between saturated sediment and river water.

Monitoring wells located near the Columbia River will provide information on what is migrating towards the river with ground water, and these data can be used as a conservative estimator of what is potentially discharging into the Columbia River, either via seepage along the riverbanks or through riverbed sediment. Water quality measurements, radiation surveys, and biota sampling, which are conducted as part of the Hanford Environmental Surveillance Program, will be used in conjunction with the data obtained through field surveys for the 100-KR-4 operable unit, to interpret the public health and safety risk associated with the shoreline along the 100-K Area.

Actual measurement of contaminated ground water seepage into the Columbia River through the riverbed would be difficult without specially constructed equipment. The problem is to trap a sample of saturated sediment, with either a grab or core-type sampler, and then isolate it from dilution with river water as it is returned to the surface. An alternative method may involve equipment that could obtain an in situ sample of sediment pore water. While highly desirable to obtain such samples as part of an overall assessment of the impact Hanford Site contaminants have on the Columbia River system, the work is more appropriately conducted under a separate research program. Collecting grab samples for the purpose of analyzing particulates only does not suffer from this difficulty.

Particulate contamination was discharged directly into the Columbia River through riverbed outfalls during the reactor operating period (see Section 3.1.4.4). It is possible that some of that material remains in depositional areas in the immediate vicinity of the outfall; some of it is known to have accumulated in downstream depositional areas such as McNary Dam (Jaquish and Bryce 1989). A reconnaissance sediment sampling program will be conducted to determine the distribution of radionuclide contamination in the vicinity of the outfall.

It is likely that contaminants from sources other than 100-K Area facilities are present in both Columbia River water and sedimentary deposits, where particulate contamination from an upstream source may be concentrated by the natural depositional processes of the Columbia River. As a result, the field sampling proposed in this task may identify zones of contamination along 100-K Area shoreline that are not products of 100-K Area operations. Regardless of the source, the concentrations and rates of discharge will be determined and used to assess the risk of public exposure as part of the 100-KR-4 operable unit.

River level data will be collected simultaneously with water level measurements in monitoring wells, to better understand the interface between ground water migrating towards the Columbia River and the influx of river water to the banks during high river levels. Similar efforts are already in progress at both the 100-H and 300 Areas, as part of RCRA monitoring projects. The mixing process apparently dilutes ground water with river water, before ground water seeps into the Columbia River (Peterson 1990). Fluctuating ground water levels may also be involved in remobilizing contamination stored in the soil column as a result of past disposal practices. Similar processes are likely to be occurring in the 100-K Area.

The surface water and sediment investigation will be coordinated with similar investigations at other shoreline operable units (e.g., 100-NR-1, 100-HR-3, 100-FR-1, and 300-FF-5) and with sample collection and radiation surveys that are conducted as part of the Hanford Environmental Surveillance Program (e.g., Jaquish and Bryce 1989). Coordination will be established to ensure sampling protocols that produce comparable data; complementary schedules and sampling locations; and exchange of interpretive results as quickly as possible.

Task 4 is divided into the following subtasks:

- Subtask 4a--Data compilation
- Subtask 4b--Field activities: (1) shoreline mapping, (2) shoreline radiation survey, (3) sampling riverbank springs, (4) river sediment sampling, (5) seepage measurement, and (6) river stage measurement
- Subtask 4c--Laboratory analysis: (1) sediment chemical properties and (2) water chemical properties
- Subtask 4d--Data evaluation.

5.1.4.1 Subtask 4a--Data Compilation. Data applicable to the 100-KR-4 operable unit relative to the Columbia River water and sediment will be obtained, inventoried, and evaluated. Existing data considered useful for this investigation will be added to the database as discussed in the DMP (Attachment 4). The database will be created and utilized to facilitate data comparisons, manipulation, and presentation. Hydrologic data from the USGS gaging station, located just below Priest Rapids Dam, will be included. Information relative to river stage and discharge in the vicinity of the 100-KR-4 operable unit will also be obtained. Ground water contamination information from near-shore ground water wells will be integrated with surface water data. Data relative to the Columbia River water and sediment quality will be included, as will data collected from applicable seeps or springs. The information gathered will be useful in characterizing the Columbia River environment near the 100-KR-4 operable unit, to optimize and adjust sample locations and times, and assist in interpreting data collected during this investigation.

5.1.4.2 Subtask 4b--Field Activities.

5.1.4.2.1 Shoreline Mapping. Areas of interest (e.g., springs, radioactive anomalies, and past construction) will be staked, photographed, and mapped on a topographic base map. This survey will be conducted at periods of low river stage to maximize the number of exposed springs. The area to be mapped will include the Columbia River shoreline along and in the vicinity of the 100-K Area. The work will focus on identifying springs and reactor-related structures along the shoreline, to help determine sampling locations. This will be conducted in conjunction with geologic mapping and with a survey of riparian biota present in this area. Several riverbank springs along the 100-K Area have been observed in the past. Emphasis will be placed on identifying shoreline spring locations previously demonstrated to be reliable or consistent discharge points (Figure 2-16).

The bathymetry of the Columbia River in the vicinity of 100-K Area will be mapped from existing survey data, river transects with depth sounders, and aerial observation of shoaling patterns. The objective will be to outline areas of sediment deposition, to aid in selecting sampling locations.

5.1.4.2.2 Shoreline Radiation Survey. A radiation survey along the exposed shoreline inside the 100-KR-4 operable unit will be conducted to identify areas of contamination. Although many of the radionuclides that may have been deposited along the shoreline have decayed away since the reactor was shut down, some of the long-lived gamma-emitting radionuclides may still be present and detectable using portable, low-level gamma radiation detectors.

Radiation surveys will be conducted on foot using low-level gamma radiation detectors. Measurement results from these surveys will be compared with background external radiation levels as measured along the shoreline upstream of the Hanford Site, with results of similar surveys conducted in the past (e.g., Sula 1980), and with applicable external radiation protection dose limits.

5.1.4.2.3 Riverbank Springs. Several riverbank springs have been observed during previous investigations (McCormack and Carlile 1984). Because these locations represent a potential exposure pathway, concentrations measured at these locations will be input to the baseline risk assessment.

The location of the exposed springs will be identified during the shoreline mapping task. River water samples will be collected adjacent to and immediately downstream of visible or suspected ground water discharge locations. Additional samples will be collected in the vicinity of the outfall structure.

Springs will be sampled at approximately the same time as the collection of ground water samples from monitoring wells. Historical water discharge data for the Columbia River at Priest Rapids Dam indicate that low seasonal flow typically occurs during September and October. This period will correspond with the late summer ground water sampling episode. Springs that flow intermittently will be sampled as closely as possible to the monitoring well sampling events. Field measurements of water temperature, pH, and specific conductivity will be during each spring sampling event.

Sampling will be conducted during low daily flow of the river to maximize the potential for obtaining representative samples of ground water seepage. If necessary, cooperation of the Bonneville Power Administration, U.S. Army Corps of Engineers, and public utility districts will be sought to provide sampling opportunities at low river stage. The sample collection protocol will follow that established by McCormack and Carlile (1984).

5.1.4.2.4 River Sediment Sampling. Samples of sediment will be collected at sites where contamination is detected during the shoreline radiation survey. Samples will be collected from those areas observed to have concentration of contaminants elevated exposure rate of 25 mR/h. Sediment grab samples will be obtained from depositional areas in the vicinity of the reactor outfall structure. The samples will be analyzed for radiation, and the sediment characteristics described using a binocular microscope.

5.1.4.2.5 Seepage Measurement. Although the spring located above the river water level represent only a portion of the total flow of ground water into the Columbia River, estimates or actual measurements of the spring flow, where possible, will be made to compare with the results obtained through modeling ground water flow. Standard velocity/area measurement techniques will be used to estimate the spring discharges. Where seepage occurs over a general area, the flow will be channeled to aid in measuring its volume. If quantitative measurement techniques are impossible, visual estimates will be made.

5.1.4.2.6 River Stage Measurement. A river-gauge station will be located on the Hanford side of the Columbia River at the 100-K Area to characterize the spatial and temporal variability of river stage. The gauge will be equipped with a stilling basin, a pressure transducer, data logger, and a staff gauge (to periodically monitor and calibrate the transducer).

5.1.4.3 Subtask 4c--Laboratory Analysis. Sediment samples will be tested for the 'short list' of chemical properties (Table 5-1) and contaminants of concern. Water samples will be analyzed for the 'short' list of analytical parameters (Table 5-2) and contaminants of concern. The selection of the analyses of concern for water samples will be based on the results of the initial comprehensive ground water sampling round. Water temperature, pH, and conductivity will be measured while collecting water samples.

5.1.4.4 Subtask 4d--Data Evaluation. Surface-water and sediment data will be used in determining risk assessments for shoreline exposures and surface water pathways. Radiation surveys will be interpreted to assess radiation exposure levels at known discharge locations and riverbank springs and will guide future sampling efforts.

Locations, elevations, water quality, and flow rates of springs along the riverbank will be plotted, and water quality data will be evaluated to determine whether or not preferred ground water discharge pathways to the river exist. Hydrographs for the Columbia River will be compared to water level data from wells and to chemistry data. Hydrographs will be used in the data evaluation subtask of the ground water investigation.

Surface water chemical concentrations will be used to evaluate dilution of ground water discharges at the ground water/surface water interface. These data will be used as input to assess environmental pathways along the riparian area.

5.1.5 Task 5--Vadose Investigation

The purpose of the vadose zone investigation in the 100-KR-4 operable unit Phase I RI is to provide information on soil chemistry and physical properties as they relate to potential impacts on ground water (e.g., recharge potential) and to provide supporting information for the 100-KR-1, -2, and -3 source operable unit RIs. Sampling and analysis of the vadose zone materials will be conducted in conjunction with the monitoring well installation.

The vadose zone information will be used to evaluate: (1) the potential for infiltration of precipitation and process water, (2) the extent of contamination in the vadose zone emanating from historic and existing source areas, and (3) the exchange of contaminants between soil in the vadose zone and the ground water (and the subsequent spread of these contaminants) as a result of ground water mounding during site operations and river level fluctuations. Soil physical parameters collected from outside of source areas are not necessarily representative of conditions within source areas. These areas must be characterized separately. The characterization of soil hydraulic properties is most appropriately done in the source area RI/FS.

The 100-KR-4 operable unit vadose investigation (Task 5) consists of the following four subtasks:

- Subtask 5a--Data compilation
- Subtask 5b--Field activities
- Subtask 5c--Laboratory analysis
- Subtask 5d--Data evaluation.

Work in the first and last subtasks (i.e., data compilation and data evaluation) will be performed as part of similar subtasks in Task 6 (Sections 5.2.6.1 and 5.2.6.4, respectively). For example, data compilation will include review of available geologic logs, which must also be reviewed as part of existing well evaluation. Work in the other two subtasks, field activities and laboratory analysis, is specific to the vadose zone investigation and is described in this section.

5.1.5.1 Subtask 5b--Field Activities. The vadose zone investigation includes one field activity (sampling for soil chemical analyses). Sampling will be conducted in conjunction with the installation of the ground water monitoring wells; therefore, drilling methods are discussed in Section 5.2.6.2.2. Collection of samples for physical testing is discussed in Section 5.2.6.2.2. However, the sampling requirements for chemical sampling are discussed under this task because chemical analyses will only be performed on one sample collected from below the water table. These wells are: K19B, K20A2, K27A2, K32A1, K33A1, K34B, K35A1, K36A1, K37A1, K38A1, K39A2, K40B, K41A1, and K43A1.

At each of the proposed well or well cluster locations, shown on Figure 5-1, soil samples will be collected for soil chemical analysis at 5-ft (1.5-m) intervals from ground surface to 20 ft (6 m) below surface and at 10-ft (3-m) intervals from 20 ft (6 m) below surface to the water table. One sample will also be collected 5 ft (1.5 m) below the water table. Only the deepest well of the cluster sites will be sampled. All wells will be subject to field screening and selective sampling at the discretion of the well site geologist. In wells being sampled, samples will be collected where lithologic changes are noted. Sampling intervals were selected to determine not only the presence or absence of specific chemical constituents, but also the spatial variation in their concentrations. These sampling intervals should allow for correlating variations in parameter concentrations with lithology and with the zone of water level fluctuations. A select number of samples will be archived for testing conducted in Phase II or for other Hanford Site programs (e.g., adsorption/desorption tests).

All the samples will be screened in the field for radionuclides and volatile organic compounds and for visual contamination. In addition, a strategy for using other screening methods (i.e., x-ray fluorescence (XRF), specific conductance, ion selective electrode, head space/gas chromatography (GC), solvent extraction/GC, and high resolution spectral gamma) will be developed based on experience gained at other Hanford Site operable unit RI's. The screening program will be developed to determine if correlation exists between the results from screening methods and standard laboratory analysis methods. The document, *A Proposed Data Quality Strategy for Hanford Site Characterization* (McCain and Johnson 1990) will be used as guidance. If field screening indicates additional analyses are warranted, appropriate parameters will be selected.

5.1.5.2 Subtask 5c--Laboratory Analysis. All of the samples will be analyzed for the short list of chemical constituents, except for the samples from 15, 30, and 50 ft and the sample from below the water table, which will be analyzed for the long list of constituents. Emphasis has been given to analyze for contaminants with a higher affinity for adsorption although comprehensive analyses are proposed at select locations and depths. If field screening indicates additional analyses are warranted, appropriate parameters will be selected.

A data validation process, particularly for laboratory data, is conducted as the data are generated. A description of the data validation plan for the 100-KR-4 operable unit is included in the QAPP (Attachment 1, Part 2). Data validation is a quantitative and qualitative review of specified QA/QC parameters; laboratory precision and accuracy; method blanks; field blanks; instrument calibration; and holding times. This review will assess the suitability of the data relative to subsequent RI data reduction, evaluation of remedial alternatives and risk assessment.

5.1.6 Task 6--Ground Water Investigation

The purpose of the ground water investigation is to determine the nature, extent, and movement of ground water contamination in the hydrostratigraphic units underlying the 100-K Area. The investigation will be conducted in phases to allow adjustment as site knowledge is enhanced. The Phase I investigation is designed to provide information on the overall conditions beneath the 100-K Area as well as to specify sources that may have significant impact on ground water. The Phase I investigation results will be used to conduct a baseline risk assessment, to assess ARARs, and to evaluate remedial alternatives in an FS. A second phase of investigation may include: (1) tasks that provide more specific data to support an FS or risk assessment, (2) source-specific monitoring at solid waste facilities not addressed during Phase I, or (3) additional delineation of contamination or hydrostratigraphic variations found during Phase I.

The specific objectives of the ground water investigation are based on the current understanding of the site hydrostratigraphy. As the hydrostratigraphic model is refined during implementation of the 100-KR-4 operable unit work plan, these objectives may need to be refined. The objectives are as follows:

- Determine the condition of existing monitoring wells. The number and location of wells installed during this investigation are partially dependent on the utility of the existing wells.

- Verify the current interpretation of subsurface lithologic and hydrologic conditions. The proposed screened intervals for new wells are based on potential vertical barriers to ground water flow, such as the cemented gravel and clay layers noted in the drillers' logs.

- Measure the physical and chemical characteristics of the hydrostratigraphic units that are the 100-KR-4 operable unit. Specific measurements for each water-producing unit include hydraulic head, hydraulic conductivity, and ground water quality. The principal measurement on confining units is vertical hydraulic conductivity. This information will be used to determine contaminant distribution and calculate ground water flow rates in the different hydrostratigraphic units, to calculate contaminant flow rates, and to project potential source impacts on ground water conditions. It will also be used to verify the current interpretation of ground water contaminant distribution.

- Evaluate the ground water/surface water interaction by comparison of water level measurements in the monitoring wells with the river level and water quality in the wells and seeps.

- Coordinate ground water sampling activities with those performed for other purposes within and around the 100-KR-4 operable unit, such as environmental monitoring near the east end of the 116-K-2 trench and long-term Hanford Site environmental monitoring (e.g., sampling of Wells K27, K28, K29, and K30).

The hydrostratigraphic units and their relationship to geologic units are as follows:

- Ringold producing unit A--sand and gravel with discontinuous layers of cemented gravel; is the saturated portion of Ringold unit 1

- Ringold confining layer B--silt and clay with sand layers, equivalent to Ringold unit 2a

- Ringold confining layer C--clay and silt; equivalent to Ringold unit 2c

- Ringold confined aquifer C--sand and gravel directly overlying basalt; equivalent to Ringold unit 3

- Columbia River Basalt aquifer system--a series of aquitards and aquifers of basalt flow interiors, flow tops, and interbeds. The shallowest unit beneath the 100-K Area is the Elephant Mountain Basalt, which is believed to act as an aquitard.

In the Phase I investigation, no wells will be installed in the basalt aquifer system or in confined aquifer C. They may be necessary in later RI phases depending on the vertical extent of contamination as defined in RI Phase I. Samples from Ringold confining layer C will be collected from three proposed boreholes to obtain information about the hydraulic characteristics of the unit.

The proposed well locations are shown on Figure 5-1. A schematic of the hydrostratigraphic units relative to proposed well completion intervals is shown on Figure 5-2. Well locations are shown in relation to potential contaminant sources on Plate 2. Twenty new wells are proposed for the Phase I investigation and twenty existing wells will be evaluated for possible use. Table 5-3 lists the proposed usage for each well.

The existing 100-K Area well numbering system has been continued in this work plan. The last known well number was K31 (although the location of this well is not known). Therefore, the proposed well numbers begin with K32. In well clusters, each well will have the same number but a different suffix to indicate its hydrostratigraphic completion interval (e.g., K34A1, the water table in Ringold producing unit A. An A2 suffix indicates the well is completed in the lower portion of producing unit A. A B suffix indicates the well is completed in Ringold confined aquifer B. If wells are later drilled and completed in Ringold confined aquifer D, they will be given a D suffix.

If additional wells are added near an existing well, but at different depths, the existing well number is used and suffixes added. For example, well K19 is an existing shallow well. Two deeper wells are proposed adjacent to it and will be designated K19A2 and K19B. If an existing well is no longer usable and is replaced, a new designation will be assigned to the replacement well.

Specific information about the well locations and depths in relation to potential sources is presented below. This information is summarized in Figure 5-3 for the proposed wells. An evaluation of existing wells will be part of the initial field investigation (see Section 5.2.6.2.1). For planning purposes, the existing wells listed in Table 5-3 are assumed to be structurally and technically sound. Existing wells will be replaced if they are determined to be unusable.

Existing well K10--may be used to monitor ground water quality in the 100-KR-1 operable unit, if an evaluation of this well in subtask 6b indicates it is suitable. Slug tests may also be conducted in this well, to supplement data on aquifer characteristics of the lower portion of production unit A.

Existing well K11--may be used to serve the same general purposes as well K10, but it apparently monitors both the upper and lower portions of producing unit A.

Existing well K13--will be sampled to investigate the source of the "oil in well" noted in McGhan (1989). If there is no evidence of oil in the well or if it appears to have been due to a leaking pump or other localized problem, well K13 will not be sampled again.

Existing well K15--is located in the KR-1 operable unit. It may be used to monitor water levels and ground water quality in the top of producing unit A. Slug tests may be conducted in this well.

Existing well K19 (K19A1)--monitors Ringold producing unit A near the 116-K-2 trench in 100-KR-1 operable unit. It will be teamed with proposed wells K19A2 and K19B to provide data on vertical gradients and vertical distribution of contaminants. It may be used to monitor ground water quality and water levels. Slug tests may be conducted to supplement data on aquifer characteristics.

Proposed well K19A2--will monitor the lower portion of producing unit A near the 116-K-2 trench, in operable unit 100-KR-1. With existing well K19 and proposed well K19B, it will provide data on vertical gradients and distribution of contaminants. It may be used to monitor ground water on aquifer characteristics.

Proposed well K19B--will monitor Ringold confined aquifer B near the 116-K-2 trench. It is part of a cluster of wells (with wells K19 and K19B) and will provide data on vertical gradients and distribution of contaminants. It is one of three wells proposed for the B aquifer and will yield information on hydrologic characteristics of confining unit B and confined aquifer B in the eastern portion of the study area.

Existing well K20 (K20A1)--monitors the uppermost aquifer near the 116-K-2 trench in the 100-KR-1 operable unit. With proposed well K20A2, it will provide data on vertical gradients, vertical distribution of contaminants, and the influence of the Columbia River stage changes on ground water levels and ground water quality.

Proposed well K20A2--like well K19A2, will monitor the lower portion of producing unit A near the 116-K-2 trench in the 100-KR-1 operable unit. It is paired with existing well K20A1.

Existing wells K21 and K22--may be used to monitor water levels and ground water quality in the uppermost aquifer in the eastern portion of the 100-KR-1 operable unit. Slug tests may also be conducted in these wells.

Existing well K23--may be used to monitor water levels and ground water quality in the uppermost aquifer in the central portion of the 100-KR-1 operable unit. Slug tests may be conducted in this well.

Existing well K24--may be used to monitor water levels and ground water quality in the uppermost aquifer in the western portion of the 100-KR-1 operable unit. Slug tests may be conducted in this well.

Existing well K25--may be used to monitor water levels and ground water quality (quarterly) in the uppermost aquifer in the 100-KR-1 operable unit. Slug tests may be conducted in this well.

Existing well K27 (K27A1)--monitors the uppermost aquifer downgradient of the 105-KE fuel storage basin, in the 100-KR-2 operable unit. With proposed well K27B it will assess vertical gradients and vertical distribution of contaminants.

Proposed well K27A2--will be located downgradient of the 105-KE fuel storage basin, in the 100-KR 2 operable unit. It will be paired with existing well K27A1 and will provide data on aquifer characteristics in the lower portion of producing unit A.

Existing wells K28, K29, and K30--are completed in the uppermost aquifer downgradient of the 105-KE fuel storage basin, in the 100-KR-2 operable unit. These wells may be used to monitor ground water quality and water levels and for slug tests.

Proposed well K32A1--will be used to help define the water table, the influence of river stage changes on water levels and ground water quality, and characteristics of the uppermost aquifer. It is currently upgradient of the 100-K Area, but was downgradient when the ground water mound from effluent disposal was present.

Proposed well K33A1--will serve the same purposes as well K32A1, but is located further from the Columbia River to help assess the extent to which the river effects are important.

Proposed well K34A1--will serve the same purposes as wells K32A1 and K33A1, but is located further from the Columbia River. With proposed wells K34A2 and K34B it will assess vertical ground water gradients and ground water quality.

Proposed well K34A2--will monitor the lower portion of Ringold producing unit A upgradient of 100-K Area. Its location was formerly downgradient of 100-K Area operations. It is part of a well cluster, with wells K34A1 and K34B. This well will also provide data on geology (e.g., whether cemented zones are present) and aquifer characteristics.

Proposed well K34B--will monitor Ringold confined aquifer B upgradient of 100-K Area. Its location was formerly downgradient of 100-K Area operations. It is part of a well cluster with wells K34A1 and K34A2. This well is one of three proposed for Ringold confined aquifer B, located in a triangular pattern. Well K34B will provide data on geology and aquifer characteristics of Ringold confining layer B and Ringold confined aquifer B in the southwest portion of the study area.

Proposed well K35A1--will serve the same general purposes as well K32A1. It will provide data on the aquifer and ground water upgradient (south) of the 100-KR-4 operable unit.

Proposed well K36A1--will monitor the top of Ringold producing unit A downgradient of the 120-KW tanks. It will help define the water table in the uppermost aquifer, aquifer characteristics, and distribution of contaminants.

Proposed well K37A1--will serve the same purposes as well K36A1, but it will be located downgradient of the 120-KE tanks.

Proposed well K38A1--is located in the KR-2 operable unit and will monitor the uppermost aquifer downgradient of the west reactor and associated facilities. It will also help define the water table and aquifer characteristics in the top of Ringold producing unit A.

Proposed well K39A1--will serve the same purposes as well K38A1 but will monitor the area downgradient of the 118-K solid waste burial ground. With proposed well K39A2 it will measure vertical gradients and vertical contaminant distribution.

Proposed well K39A2--will monitor the lower portion of producing unit A in conjunction with well K39A1. Well K39A2 will help define lithologic and hydrologic characteristics of the lower portion of producing unit A.

Proposed well K40A1--is located in the 100-KR-1 operable unit and will monitor the uppermost aquifer downgradient of the 116-KW-3 retention basins. It is one of a cluster of wells that will assess vertical gradients and vertical distribution of contaminants. It will also help define the water table and aquifer characteristics in the top of Ringold producing unit A.

Proposed well K40A2--will monitor the bottom of Ringold producing unit A downgradient of the 116-KW-3 retention basins. It is one of a cluster of three wells. It will also provide lithologic and hydrologic data for the lower portion of producing unit A.

Proposed well K40B--will monitor Ringold confined aquifer B downgradient of the 116-KW-3 retention basins. It is one of a cluster of three wells. Well K40B is one of three proposed for the B aquifer, and it will provide data on hydrogeologic conditions in the B aquifer and confining unit in the northwestern portion of the study area. This borehole will provide lithologic and hydrologic data on the top of Ringold confining unit C.

Proposed well K41A1--is located in the 100-KR-2 operable unit and will monitor the top of producing unit A downgradient of the 118-K-3 filter crib. It will help define the water table, river influence, and aquifer characteristics.

Proposed well K42A1--is located in the 100-KR-1 operable unit and will monitor the top of producing unit A downgradient of the east end of the 116-K-2 trench. It is the furthest east of the proposed wells and will provide data on the water table, influence of river stage, and aquifer characteristics.

Existing well 6-72-73--is located upgradient and southwest of the 100-KR-4 operable unit, outside the operable unit boundaries. It may be used to monitor ground water quality and water levels in the uppermost aquifer. Slug tests may be conducted in this well.

Existing well 6-70-68--is located upgradient and south of the 100-KR-4 operable unit, outside the operable unit boundaries. It may be used to monitor ground water quality and water levels in the uppermost aquifer and to perform slug tests.

Existing wells 6-66-64 and 6-73-61--are located upgradient and south of the 100-KR-4 operable unit, outside the operable unit boundaries. These wells may be used to monitor ground water quality and water levels and for slug tests. It is uncertain which portion of producing unit A these wells monitor.

Existing well 6-81-62--is located upgradient of the K-Area, south of the eastern edge of the 100-KR-4 operable unit. It is completed in the basalt/interbed system. Data from this well may be useful in determining the gradient between the basalt aquifer system and the unconsolidated aquifers, and in monitoring ground water quality in the deeper confined aquifers.

The Phase I ground water investigation has been organized into the following four subtasks (subdivisions within each task are also identified).

- Subtask 6a--Data compilation
- Subtask 6b--Field activities: (1) evaluation of existing wells, (2) well installation, (3) water level measurements, (4) aquifer testing, and (5) ground water sampling
- Subtask 6c--Laboratory analysis: (1) soil physical properties, (2) rock chemical properties, and (3) ground water chemistry analysis
- Subtask 6d--Data evaluation: (1) chemical, (2) hydrologic, and (3) modeling.

5.1.6.1 Subtask 6a--Data Compilation and Sampling Coordination. The objective of this task is to gain an understanding of the ground water hydrology at the 100-K Area as defined by existing data. This is intended to assure that future sampling results relevant to the 100-K Area will be compiled and interpreted in one program.

A preliminary data review was conducted in preparation of the 100-KR-4 operable unit work plan. These data will be supplemented with site-specific information not reviewed during the preliminary study; hydrogeologic information collected during pre-RI activities (e.g., water level measurements, aquifer tests, ground water quality analyses, and well evaluation) in the 100-K Area; and information from relevant studies in the vicinity of the 100-K Area (e.g., RI and/or RCRA studies at 100-B/C, 100-D, 100-F, 100-H, and 100-N Areas).

One of the most important activities to be conducted during the data compilation task will be to evaluate existing ground water monitoring wells to determine the feasibility of incorporating these wells into the monitoring network for the RI. Existing wells will be evaluated on the basis of their physical condition and data produced from these wells in the past. These evaluations will determine whether they are adequate for water level measurements, water quality sampling, aquifer tests, or other activities. Drilling, logging, installation, sampling, and field verification records will be reviewed, if available. Information on depth of the well, screened interval, and construction materials will be evaluated to assess whether the wells will need to be remediated, replaced, or are adequate for some or all the potential uses.

Much of the available data are historic data, (i.e., collected in accordance with sampling protocols and QA/QC procedures applicable at that time). These protocols and procedures will be reviewed to assess whether the data can be used quantitatively, semiquantitatively, or only in a qualitative sense. However, because the ground water system is dynamic, historic data provide the only information on past conditions. Therefore, the historic data must be retained, if only for qualitative reference. Appropriate notations will be made if it is suspected that particular data points or data sets are erroneous.

5.1.6.2 Subtask 6b--Field Activities.

5.1.6.2.1 Evaluation of Existing Wells. Field testing or verification will be required for existing wells at the site, in conjunction with a review of existing data (i.e., drillers' logs and hydrographs) to determine whether any of these wells can be incorporated into the proposed monitoring network. Testing and verification procedures may include sounding the depth of the wells and running a downhole video camera or similar activities. The feasibility of running geophysical logs on the wells will be investigated. Location of wells which are thought to exist are shown on Figure 5-1 and Plate 2.

Existing wells may require abandonment, remediation, or replacement. Remediation may consist of sealing upper portions of the casing, if not previously sealed; addition of a surface pad and protective posts; scrubbing the interior of the casing; replacement (or addition) of a pump; redevelopment of the well, or similar activities. If well abandonment proves necessary, it will be conducted in accordance with regulatory requirements. If replacement is required, the old well will be properly abandoned and the new well will be installed in accordance with the hydrogeologic and construction requirements of this work plan. All of the existing wells will be surveyed for horizontal and vertical coordinates.

5.1.6.2.2 Well Installation. There are several operations conducted in this field activity, specifically, well siting, drilling and sampling, borehole logging, well completion, well development, and well surveying.

Well Siting--The purpose of this task is to confirm the surface and subsurface location of utilities, disposal cribs, or other buried objects at the proposed drilling locations to ensure that the health and safety of the drilling and oversite personnel are protected. Additionally, the risk of introducing additional contamination to the ground water can be reduced by avoiding drilling directly through highly contaminated areas. A site walkover survey will be conducted to evaluate access to drilling sites (Section 5.2.2.2.1).

This task may not be necessary at some locations if the required geophysical and radiation data have been collected during previous studies or will be collected before well installation as part of the overlying operable unit characterization. The source and ground water operable units will share these data to avoid redundancy.

Three geophysical survey methods will be used for drill location screening: magnetometer (MAG), electromagnetic induction (EMI), and ground penetrating radar (GPR). These methods will be supplemented with a surface radiation survey. Each of the surveys will utilize the same grid dimensions in traversing the site. Details on the geophysical methods are provided in the SAP (Attachment 1).

Drilling and Sampling--The drilling and sampling program is designed to meet the requirements of the ground water investigation. In addition, the program is designed to minimize exposure of field personnel and reduce the possibility of cross-contamination between water-bearing zones.

Twenty new wells will be drilled in or near the 100-K Area. These wells are to be used in conjunction with 20 existing wells to provide a network of wells. The proposed well locations are shown along with the existing wells on Figure 5-1 and Plate 2 and listed on Table 5-3. At three of the locations (K19, K20 and K27), deeper wells will be installed adjacent to existing wells. At three other locations (K34, K39 and K40), two or more wells will be completed at differing depths. Ten other locations (K32, K33, K35-38, K41, and K42) are sited for single well completions. Well locations may be modified as a result of the following:

- New hydrogeologic information
- Site accessibility problems
- Underground obstructions
- Surface contamination.

Cable-tool drilling is the method of choice for this task because the quantity of drilling residuals is minimal compared with alternative methods (air rotary or mud rotary), and the discharge of formation water and cuttings from the hole can be easily controlled. However, other drilling techniques may be considered, as discussed in the following paragraph.

Cable-tool drilling must be used at all wells until the upper permeable aquifer zone is penetrated and cased off. Thus, cable-tool drilling will be used at all single (shallow) well locations. At cluster sites, the deepest hole will be drilled first; cable-tool drilling will be used for the total depth on this initial hole. If the results of field monitoring and chemical sampling indicate that the location is void of contamination, then an alternative method (mud rotary) may be considered on subsequent holes at the location. In any event, the 'starter holes' (i.e., the first stage through the upper permeable zone) will be drilled with cable tool.

At cable tool holes, drive casings will be telescoped to minimize cross contamination between hydrostratigraphic zones, and as required for casing pull-back. As a minimum, distinct hydrostratigraphic units and contaminated zones shall be cased off and sealed before preceding downward with further drilling. Borehole and casing configurations will be determined in a design review process.

Soil samples for chemical and physical property analyses will be collected from the deepest borehole at each of the proposed locations. The samples for chemical analyses will only be collected to 5 ft below the water table, as discussed under Task 5. The samples for physical property analyses will be collected both above and below the water table at 5-ft (1.5-m) intervals from the ground surface to 20 ft (6 m) below surface, water table, and below the water table at changes in lithology. All samples will be analyzed for grain size, soil classification, and CEC. Samples above the water table will be analyzed for moisture content. Permeability testing will be performed at the discretion of the onsite geologist.

Several methods of sampling may be employed for sampling soils from monitoring well borings. However, because of the natural variability of geologic materials, the most appropriate sampling equipment cannot be specified in advance. In general, sampling should be done in accordance with EII 5.2, Soil and Sediment Sampling. Conditions may be encountered that require that less precise methods be used. For example, the formation may be too coarse to sample with any drive method, so cuttings may be collected from a discrete zone. This may limit the range of appropriate laboratory analyses for such a sample.

Borehole Logging--The purpose of the logging program is to provide a record of the geologic and hydrologic conditions encountered in the boreholes, as well as other pertinent information. Both geologic and geophysical logging will be conducted.

Geologic logging will be conducted on each well by a qualified site geologist or hydrogeologist. The geologic log will contain a description of the borehole lithology and observations of occurrences of water changes in drilling rate, fluid return, sample intervals, and similar items.

Geophysical logs will be run on the deepest borehole at each of the proposed drilling locations. Natural-gamma/spectral-gamma logs will be used to differentiate lithology and also to delineate radioactive contamination. Gamma-gamma and neutron-epithermal logs will be used to identify relatively permeable and impermeable lithologic horizons. To be used effectively, these logs must be calibrated to account for the temporary casing used during the drilling process. Other logs may also be run (at the discretion of the well site geologist or hydrogeologist).

Well Completion--Wells will be installed after the boreholes are completed. The design and specifications for these wells will be developed. Generally, it is proposed that the wells be completed with 4 in. (10 cm) ID, 304 stainless steel, flush-threaded casing and wire-wrapped well screen. Positioning of the screens shall be determined by the well-site geologist or hydrogeologist based on data needs and the in situ hydrostratigraphy as determined from the borehole logs. A schematic of the proposed well completion depths is shown on Figure 5-2.

Well Development--Well development will occur in two stages. The first stage will be done after the sand pack has been set and before installation of the annular seal. Additional filter sand may need to be added as the sand settles to meet well design criteria. Stage 2 development will not be conducted until at least 24 hr after installation of the annular seals to allow them to set.

Well Surveying--After the protective casing is cemented in place, wells will be surveyed for horizontal control and elevation of the well head. The survey will be conducted in accordance with EPA standards (EPA 1987). Existing wells will also be included within the well survey.

5.1.6.2.3 Water Level Measurements. Water level elevations will be measured in the 100-K Area and vicinity wells on a monthly basis. The purpose of this activity is to provide data for determining ground water gradients for and between hydrostratigraphic units of interest. The measurements will be taken to the nearest 0.01 ft (0.003 m). These data will be used to evaluate seasonal water level trends and horizontal and vertical gradients in the A1-, A2-, and B-level wells. Also, the hydraulic connection between the Columbia River and the shallow aquifer system will be evaluated to estimate the average rate of ground water discharge to, and recharge from, the river and to ascertain ground water flow directions near the river. Pressure transducers will be placed in wells along lines parallel and perpendicular to the Columbia River for more frequent measurements of the ground water level. More frequent measurements of water levels will be initiated if data from the continuous water level recorders indicate that monthly measurements are inadequate.

5.1.6.2.4 Aquifer Testing. It is advisable to postpone 'conventional' aquifer testing until Phase II of the RI when initial ground water sampling results are available to obtain information on the potential hazards and waste disposal concerns. If such testing is conducted, the aquifer test plan will be developed. The small diameter of the monitoring wells (4-in. [10-cm] casing is proposed) will limit the size pump that can be used in aquifer tests. If these pumps cannot create enough drawdown to produce useful aquifer test data, a larger-diameter well may need to be installed in Phase II for aquifer testing.

Where possible (i.e., in areas of lower permeability and on wells noted as poor producers during development) 'slug' tests will be conducted. Slug tests are based on 'instantaneous' displacement of a known volume of water in a well, by either removal or displacement, and measuring the rate of water level recovery (rise or fall) in the well. Displacement involves using compressed air or inert gas such as nitrogen or a slugging rod. If a well can be pumped dry fast enough, this is the best method for removal of a known volume of water. Pumping a well dry (instantaneously) is generally the best method of slug testing in a relatively permeable aquifer. Such a test could be incorporated into the last stage of well development or into purging before sampling. Slug tests are limited because storage coefficients cannot be calculated and the test results are representative of conditions only in the immediate vicinity of the particular well tested. (The effect of gravel pack around a well also may need to be considered.) In addition, they provide limited information on vertical aquifer permeability and in higher permeability sediments may not produce useable results.

The influence of the daily cycle of surface-water fluctuations on the rate of change in water levels (wave propagation) in ground water monitoring wells will be evaluated, using the cyclic evaluation technique (Ferris 1952) to provide additional information on aquifer transmissivity and storativity. This activity requires coordinated water level measurements in both the ground water wells and river. Aquifer transmissivity and storativity can be determined from the response function between ground water levels and the river. This can be done for large areas near the Columbia River, yielding large-scale estimates of aquifer properties under natural conditions.

5.1.6.2.5 Ground Water Sampling. Ground water samples may be collected early in the Phase I investigation from existing wells that are determined to be suitable (Section 5.1.6.2.1). These data will be useful to determine chemistry expected in the new wells. After the new wells are complete, all the new and existing wells within the 100-KR-4 operable unit and selected 600 Area wells will be sampled. The initial sampling round will be comprehensive for about one-half of the wells. The other wells will be sampled for parameters known to be present at concentrations in excess of guidelines. If VOCs are detected during drilling of a well adjacent to a liquid waste site, that well will also be sampled for volatile organic compounds. The first full round of sampling will be conducted no less than 2 weeks following the completion of the final new well installation.

Nearly half of the wells will be analyzed for the extensive list of parameters; the remaining wells will be analyzed for a short (less extensive) list (Table 5-2). These wells were chosen based on their location relative to potential contaminant sources, the river, existing wells and well completion depth.

After the comprehensive first sampling round, selected wells will be sampled monthly for 6 months; additional wells will be sampled quarterly (Table 5-3). After the first 6 months, a suitable sampling interval will be selected. The parameter list will be refined from initial test results. As a minimum, spring and fall sampling will be conducted to correspond to the seasonal high and seasonal low ground water levels.

Dedicated sampling equipment will be installed in each well in the sampling network. Field parameters (pH, temperature, conductivity) will be measured during purging and following sampling. Efforts should be made to coordinate well sampling with other concurrent well-sampling projects.

As activities in the 100-K Area intensify, efforts to coordinate ground water sampling and reporting must increase accordingly. For example, maps of contaminant plumes should be based on data collected over as short a time period as possible to obtain a ‘snapshot’ of existing conditions; therefore, it would be helpful to conduct the ground water and spring sampling in the same time frame. Also, several of the operable units physically overlap or are in close proximity. In particular, the eastern margin of the 116-K-2 trench is close to the western margin of the 100-N Area. Therefore, data obtained from the vicinity of these two areas should be compared. There is also the potential for offsite contamination migrating from the vicinity of well 6-66-64 toward the 100-K Area.

Duplicate sampling should be avoided. For example, the four wells in the vicinity of the fuel storage basin (K27, K28, K29, K30) are currently being sampled quarterly. Schedule and parameter lists will be integrated between programs.

5.1.6.3 Subtask 6c--Laboratory Analysis. Laboratory analyses will be performed on both soil (or rock) and ground water samples. The analyses of the soil/rock samples will include determination of the physical and chemical properties of the material. The ground water samples will also be analyzed for chemical characteristics.

5.1.6.3.1 Soil Physical Properties. Soil physical parameters to be determined include grain size distribution, soil classification, cation exchange capacity, moisture content and permeability. Wells will be sampled and tested as shown on Table 5-4 and detailed in the FSP (Attachment 1, Part 1).

5.1.6.3.2 Ground Water Chemistry Analysis. A data validation process is conducted as data are generated and should be completed before further data evaluation occurs. A description of the data validation plan for the 100-KR-4 operable unit is included in the QAPP (Attachment 1, Part 2). Data validation is a quantitative and qualitative review of specified QA/QC parameters; laboratory precision and accuracy, method blanks, field blanks, instrument calibration, and holding times. This review will assess the utility (quality) of the data for subsequent RI data reduction, evaluation of remedial alternatives, and risk assessment.

5.1.6.4 Subtasks 6d--Data Evaluation. Data collected during the Phase I investigation will be evaluated to define the hydrologic and water quality conditions of the ground water system in the 100-KR-4 operable unit. The evaluations of data from the geologic, vadose, and surface water and sediment investigations will be reviewed concurrently to provide information on the interaction of these systems.

5.1.6.4.1 Water Quality. To assess the shallow ground water conditions, concentration contour maps of select analytes from A1-level wells will be prepared and evaluated. Current and historic sampling data will also be compared. Concentration versus time may be continued (if appropriate) to track the data.

Chemical data for the A1-, A2-, and B-level completions will be compared to evaluate the communication between the aquifers and assess the impact of Hanford Site operations in the zones identified.

5.1.6.4.2 Hydrogeology. Physical properties of the flow systems will be evaluated to estimate the rate and direction of ground water flow in each targeted hydrostratigraphic zone. Values of hydraulic conductivity estimated from the aquifer tests and from other 100 Area wells will be used for Phase I calculations of ground water flow rate, ground water/surface water measurements, and velocity. Water level elevation data will be used to prepare water level contour maps of the shallow aquifer system. Water level maps will not be prepared for deeper zones. Water levels will be plotted on a monthly basis as the data are collected. A hydrograph of each of the wells will also be developed as the data are available.

5.1.6.4.3 Modeling. Analytical and numerical modeling may be used at the 100-KR-4 operable unit to assist in the evaluation of risk or in assessing the potential impact of remedial alternatives. Modeling will be performed only at the end of the Phase I investigation so sufficient data will be available for model calibration (i.e., comparison of actual and mathematical conditions). Saturated and unsaturated flow and solute transport models, such as UNSAT-H, VAM 2D, or PORFLO-3, are being used to model other areas of the Hanford Site. It is anticipated that one or more of these models will be applied to the 100-K Area. Participation in any regional modeling effort using codes and modeling criteria (such as boundary conditions and mesh geometry) compatible with regional model(s) will be performed during or after the Phase II investigation, if necessary.

5.1.7 Task 7--Air Investigation

The air investigation for the 100-KR-4 operable unit will be limited to monitoring for VOCs and radiation. Sampling for particulates will occur during field activities as part of the health and safety program. Site-specific monitoring for specific gases or vapors may be performed if a need is indicated. Monitoring procedures, instrumentation, and applicable standards and action levels are presented in the HSP (Attachment 2).

The primary focus of this study is ground water contamination. Therefore, ambient air monitoring beyond that necessary to ensure the safety of field personnel is not proposed for the 100-KR-4 operable unit. Sitewide issues will be addressed in the individual source operable unit investigations.

5.1.8 Task 8--Ecological Investigations

The biota investigation has the following objectives:

- Determine significant pathways and affected species
- Provide information necessary to complete the risk assessment
- Provide information necessary to evaluate the potential biological effects of proposed remediation alternatives.

The data required from the monitoring program include determination of significant potential pathways of contaminant movement to humans, determination of critical habitat for species of special concern, and conceptual models of human and environmental risk.

Sufficient data are currently available in existing studies to provide at least qualitative descriptions of ecosystem structure, and to propose provisional estimates of pathways and potential risks. To provide the most efficient use of resources, the biological studies will proceed incrementally and will correspond with the biologic studies planned for the 100-KR-1 operable unit. The approach produces the following subtasks:

- Compile all existing data on the 100-KR-4 operable unit and related 100 Area sites
- Refine field investigation plan on the basis of identified data gaps
- Predict impacts to human health and the environment
- Conduct field investigations to determine the suitability of the compiled data for use in 100-KR-4 operable unit studies and to collect additional data needed to refine the site conceptual model and complete the risk assessment.

5.1.8.1 Subtask 8a--Data Compilation and Review. A description of the aquatic and riparian biota is given in Section 2.2.6. Existing regional and site-specific biological data will be collected. This task will focus on work performed as part of the ongoing Hanford Environmental Monitoring Program, on special studies conducted at the Hanford Site, and on information available from the Department of Wildlife and the Department of Natural Resources, as well as the Washington State Natural Heritage Program. Emphasis will be placed on using data developed during investigations at other operable units in the 100-K Area.

Existing data will be used to identify aquatic species with protected management status that occur at the site; species that are dominant in the community in terms of productivity, abundance, or biomass; and species whose removal from the ecosystem would result in a dramatic change in the characteristics of the system. Probable pathways of contaminant transfer in the environment will also be identified.

These data will give direction to the field monitoring program, and will provide information needed for other tasks in the study. The field investigation will concentrate on areas of known contamination in the 100-KR-4 operable unit, and on species with demonstrated potential to translocate contaminants of concern.

5.1.8.2 Subtask 8b--Field Activities. It is expected that transport of chemical contaminants from the 100-KR-4 operable unit through ground or surface water is low and that the uptake of these contaminants by plants will also be minimal. However, shoreline plants as primary producers may constitute a significant exposure route for herbivores from contaminants assimilated in plant tissues. A walkover survey will be conducted to identify the general site riparian inventory. A baseline study will be conducted if existing data is lacking or if current conditions warrant such action.

To determine the concentration of chemical contaminants in riparian plants, reed canary grass will be sampled at sites adjacent to springs that show significant levels of contamination. One composite sample will be collected at spring locations that have been identified for sampling under subtask 4b. Trees have deeper root systems than herbs and can take up ground water from greater depth. When available, leaves of trees (mulberry) will be sampled for the leaf-water concentration of tritium. Sampling activities will be coordinated with the spring sampling events.

In addition to reed canary grass, walking surveys will be made to locate any riparian plants that might be collected and eaten by people boating the Hanford Reach. Special searches will be made to locate clumps of wild asparagus. If asparagus plants occur in or adjacent to the 100-KR-4 operable unit, samples will be collected and analyzed during the season when they are most likely to be harvested by people.

Sampling will supply information about contaminant concentrations in plant tissues collected in the vicinity of the 100-KR-4 operable unit riparian zone and enable comparisons of these values with 'control' areas. If values are significantly elevated over background control values, herbivorous animals will be harvested and their tissues analyzed for specific contaminants. There are a variety of organic and inorganic contaminants that could also be bioaccumulated in animal tissues. Biomagnification is well documented in the literature, and thus low levels of contaminants found in plants may be indicative of elevated levels in wildlife. When elevated concentrations in plant tissues are found, mice and/or cottontail rabbits will be selected for harvest because they have restricted home ranges, are herbivores, and are usually available in numbers sufficient for sampling and monitoring.

Sampling programs established to document contaminant concentrations in aquatic biota, particularly vertebrates most likely to be involved in food webs leading to humans, have shown very low to no discernable level of contamination. However, a baseline sampling program will be established to document contamination concentrations in lower trophic organism (periphyton and macroinvertebrates) if spring, sediment and riparian analyses yield significant (i.e., above reference criteria or background) results.

5.1.8.3 Subtask 8c--Laboratory Analysis. Composite samples of reed canary grass (and wild asparagus if applicable) will be air dried and analyzed for radioactive contaminants (^{60}Co, ^{90}Sr, and ^{137}Cs). As indicated, tree leaf water (if available) will be analyzed for tritium. Sampling and analyses of riparian zone plants will be completed and evaluated before initiating sampling of animals.

5.1.8.4 Subtask 8d-Data Evaluation. After completion of the biota field studies, data will be evaluated to see if the provisional understanding developed from the existing data is supported. In addition, any gaps in the data that remain, or that develop from the field studies, will be identified. If data gaps exist, or if anomalous results are obtained in initial field studies of biota, additional field studies of biota will be developed to attempt to resolve the uncertainty.

If provisional understanding is supported by the field data, and no data gaps are evident, no further field studies will be conducted for this portion of the work plan.

5.1.9 Task 9--Cultural Resource Investigation

A cultural resource investigation has identified the location of surficial archaeological or historical sites listed on or eligible for the National Register of Historic Places. However, additional archaeological sites may exist along the Columbia River immediately adjacent to the 100-K Area and will be part of the 100-KR-4 investigation.

The activity will involve verifying the locations of known archeological sites by reviewing available data on historic land uses by local Indian tribes as well as early land use by pioneer farmers and settlers. The focus of the investigation will be to determine whether archaeological resources are present at proposed drilling sites. A Class 3 field survey will be conducted by a qualified archaeologist as part of the initial RI field activities. *Hanford Cultural Resource Management Plan* (Chatters 1989) will be followed during all review processes. No RI field work will be performed in areas of known sites before completion of this task.

5.1.10 Task 10--Data Evaluation

This task consists of compiling and integrating the results from each of the data evaluation subtasks of each investigation (Tasks 2 through 9). A conceptual model will be constructed to describe: (1) the quantities and concentrations of specific contaminants at the operable unit, (2) the number, location, and types of nearby populations and activities, and (3) the potential transport mechanism and the expected fate of the contaminant in the environment.

5.1.11 Task 11--Baseline Risk Assessment

The objective of the baseline risk assessment task is to determine the magnitude and probability of potential harm to human health or the environment by the threatened or actual release of a hazardous substance from a waste site in absence of remedial action. Results of risk assessment are used to determine and justify remedial actions. The EPA documents discuss in detail the two main areas of a baseline risk assessment: human health assessment (EPA 1989a) and ecological assessment (EPA 1989b).

To achieve this objective, the following areas will be identified and characterized:

- Quantity and concentrations of hazardous substances present in air, soil, ground water, surface water, sediment, and biota
- Environmental fate and transport mechanisms within specified environmental media, such as physical, chemical, and biological degradation processes and geohydrologic conditions
- Potential exposure pathways and extent of actual or expected exposure
- Potential human and environmental receptors
- Extent of expected impacts and the potential for such impacts occurring (i.e., risk characterization)
- Acceptable levels of exposure based on regulatory and toxicological information.

The risk assessment process is composed of the following components that, collectively, address the areas identified:

- Contaminant identification
- Exposure assessment
- Toxicity assessment
- Risk characterization.

Figure 5-4 shows how these four components interrelate.

5.1.11.1 Contaminant Identification. The first component of the risk assessment process is to identify contaminants of concern. The objective of this component is to screen the field of contaminants to provide a list of contaminants for which the subsequent risk assessment activities are focused. The basis for selecting contaminants of concern will include their persistence, mobility, intrinsic toxicological properties, presence in large quantities, or presence in media of potentially critical exposure pathways such as a source of drinking water.

5.1.11.2 Exposure Assessment. The objective of exposure assessment is to estimate the environmental concentrations of hazardous substances so that the extent and duration of human and environmental exposure can be predicted or determined. This objective will be achieved by identifying potential or actual exposure pathways, characterizing potentially exposed populations, and estimating both present and future exposure levels.

The first step of the exposure assessment involves identifying exposure pathways. Each exposure pathway consists of four elements: (1) a source and mechanism of chemical release to the environment; (2) an environmental transport medium, such as ground water; (3) a potential point for receptor contact with the contaminated medium (i.e., exposure point); and (4) an exposure route at the contact point, such as ingestion of drinking water or crop irrigation.

Data gathered during the preliminary assessment/site inspection, environmental monitoring activities, RI of the 100-KR-1 and 100-KR-4 operable units, and any other data sources will be used to identify the potential release sources and release mechanisms from the sources. As the release mechanism(s) for contaminants are identified (or postulated), the transport medium for the contaminants will also be identified.

The next element of the exposure pathway analysis is identifying the potential exposure points and exposure routes for human and environmental populations. This analysis involves identifying and characterizing maximally exposed individuals for a worst-case scenario and various populations for which an exposure potential exists. This characterization involves determining the number of individuals in a population, the demographics of each population, and the potential exposure routes to populations and individuals. The analysis will be used to identify exposure points for short- and long-term exposures. In addition to existing exposure points, credible future exposure points will be populated. A preliminary discussion of exposure routes and receptors is found in Sections 3.3.1.4 and 3.3.1.5.

Once this information is gathered, it will be assembled to determine the complete exposure pathways that exist for the 100-KR-4 operable unit. After potential exposure pathways are determined, environmental concentrations for each contaminant of concern or indicator chemical will be estimated at each of the identified exposure point locations. Concentrations will be estimated for each environmental medium through which potential exposures could occur as a function of time to assess short- and long-term exposures. These concentrations will be estimated by combining environmental monitoring and characterization data with numerical modeling to predict the release rates from the various waste sources. Then, the fate and transport of the contaminants in the transport medium of the exposure pathways will be determined. The fate and transport modeling will consider the environmental transport of contaminants (e.g., ground water migration), contaminant transformation (e.g., biodegradation), and mechanisms for transfer of a contaminant from one transport medium to another (e.g., sorption, volatilization). The predicted environmental concentrations and exposure route information will then be used to estimate the amount of contaminant that the various receptors potentially could intake (i.e., dosage rate).

5.1.11.3 Toxicity Assessment. The objectives of toxicity assessment are to determine the nature and extent of health and environmental hazards associated with exposure to contaminants from the 100-KR-4 operable unit. The final product of the toxicity assessment is a qualitative description of the toxic properties of each contaminant and a quantitative index of each contaminant's toxicity (i.e., acceptable exposure level).

Available contaminant-specific ARARs (e.g., maximum contaminant levels, 25 mrem/yr effective dose equivalent, all pathways) will be used as acceptable levels for human exposure unless exposure at the ARAR level results in a risk greater than 10^{-4}. Acceptable levels for other contaminants will be based on reference doses for noncarcinogens and cancer potency factors for carcinogens. These values are available in toxicity profiles (Barsotti et al., 1988).

Environmental hazard assessment will determine actual or potential effects of contaminants on plants and animals. Acceptable levels for environmental receptors (e.g., various species of fish) will correspond to contaminant toxicity levels available in the literature.

5.1.11.4 Risk Characterization. The final component of the risk assessment process is characterizing the risk to various receptors from exposure to contaminants from the 100-KR-4 operable unit. This objective is attained by integrating the information gathered during exposure and toxicity assessments to characterize the potential or actual risks resulting from contaminants released from the 100-KR-4 operable unit. These include the carcinogenic, noncarcinogenic, and environmental risks.

Potential human risks from the 100-KR-4 operable unit will be assessed by comparing acceptable contaminant exposure levels with actual or predicted levels. For noncarcinogens, the goal will be exposure such that the sum of fractions of actual or predicted exposure versus the reference dose is less than one. The goal for exposure to carcinogens will be a lifetime risk of contracting cancer between 10^{-6} to 10^{-4}.

The environmental risk evaluation will discuss the effects of exposure on indigenous species, food chains, and habitat. All of these factors affect environmental quality in the vicinity of the 100-KR-4 operable unit and along exposure pathways.

The final assessment will include a summary of risks associated with the 100-KR-4 operable unit, data associated with each step of the risk assessment process, estimated uncertainty of various parts, assumptions made during the assessment, and distribution of risk across different segments of the population and environment.

The results of the risk assessment will be used to determine whether the 100-KR-4 operable unit poses a potential threat to human health or the environment. The results will be the primary means of documenting the decision for choosing the no-action alternative or performing remedial action. If the no-action alternative is not selected as the preferred alternative for addressing hazards at the 100-KR-4 operable unit, remedial alternatives will be assessed as part of the FS. Comparison of the no action alternative to other alternatives may be necessary under some circumstances such as if the no action alternative is selected assuming that natural attenuation may bring contaminant concentrations to below health-based levels within a reasonable time. The risks for each of the remedial alternatives will also be assessed, but they are beyond the scope of the current effort.

5.1.12 Task 12--RI Phase I Report

A preliminary RI report documenting site characterization findings will be developed at the end of the Phase I. In addition, summary reports of characterization activities will be prepared. These reports summarize site data at the completion of each field sampling and analysis phase.

5.1.12.1 Subtask 12a--Report Preparation. An interim report will be prepared at the end of the RI Phase I. This report will consist of a preliminary characterization summary of contamination for the 100-KR-4 operable unit. Information pertinent to the operable unit conceptual model will be refined as necessary; sources of contaminant releases will be more definitively identified; the nature and extent of contamination within the operable unit sources, soils, air, and aquatic biota will be described; a definitive list of contaminant- and location-specific ARARs will be provided; and the risks associated with the contaminant releases will be presented.

5.1.12.2 Subtask 12b--Report Review. This report will be prepared primarily for interim internal review, although EPA and Ecology have the option to comment on it. It will also provide a means for communicating findings to the project FS coordinator for use in the ongoing evaluation of potential operable unit remedial action measures.

5.2 REMEDIAL ALTERNATIVES DEVELOPMENT

The objective of the FS is to develop a range of potential remedial alternatives that are protective of human health and the environment. A range of remedial alternatives for operable unit problems will be developed.

The development of alternatives for the 100-KR-4 operable unit must be coordinated with the same activity for the 100-KR-1 operable unit to ensure that overall remediation objectives can be attained. Remediation options being considered for the 100-KR-4 operable unit could affect the choice of options being considered for the 100-KR-1 operable unit.

The following four tasks will be utilized to develop remedial alternatives:

- Task 1--Project Management
- Task 2--Alternatives Development
- Task 3--Alternatives Screening
- Task 4--FS Phase I/II Report: Remedial Alternatives Development.

5.2.1 Task 1--Project Management

This task is necessary to meet the goals and objectives of the 100-KR-4 RI/FS and is discussed in Section 5.1 and the PMP (Attachment 3).

5.2.2 Task 2--FS Phase I Alternatives Development

Section 3.4 presented a general identification of remedial action objectives, general response actions, remedial technologies, and a preliminary list of remedial actions alternatives for the 100-KR-4 operable unit. These preliminary response actions, technologies, and alternatives will be modified, as appropriate, based on the evaluation of RI data and the risk assessment. The development of remedial alternatives will be accomplished in the following steps:

- Subtask 2a--Development of remedial action goals objectives
- Subtask 2b--Development of general response actions
- Subtask 2c--Identification of potential remedial technologies
- Subtask 2d--Evaluation of process options
- Subtask 2e--Assembly of remedial alternatives
- Subtask 2f--Action-specific requirement identification
- Subtask 2g--Evaluation of data needs

- Subtask 2h--Feasibility study report Phase I - remedial alternatives development.

Each task is summarized below. Additional details can be found in EPA's interim final RI/FS guidance document (1988a).

5.2.2.1 Subtask 2a--Development of Remedial Action Objectives. Remedial action objectives will be developed that state environmental medium-specific or source-specific goals for protecting human health and the environment. The environmental media of concern are ground water, surface water, river sediments, and aquatic biota. Contaminants of concern, exposure routes, receptors, and acceptable contaminant levels or ranges of levels for each exposure route will be specified for each medium. Acceptable contaminant levels will be based on identified chemical-specific ARARs, TBCs, or risk assessment calculations.

5.2.2.2 Subtask 2b--Development of General Response Actions. General response actions, which are broad classifications of actions or combinations of actions that will satisfy the remedial action objectives, will be developed on a medium-specific basis. Examples of general response actions are no action, institutional controls, disposal, extraction, excavation, containment, and treatment.

The important site and waste characteristics will be defined for the 100-KR-4 operable unit as part of this task. These characteristics will include the radiological, chemical, and physical conditions to which general response actions might be applied.

5.2.2.3 Subtask 2c--Identification of Potential Remedial Technologies. A list of potential remedial technologies will be developed for each identified general response action. The technologies to be considered should address the key site and waste characteristics identified in the RI report. Process options, which are the different processes within a technology type, will be identified for each technology.

The following example, using a hypothetical ground water situation, illustrates how the degree of technological specificity narrows in moving from general response action to remedial measure technology to process option categories:

- General response action for ground water treatment

- Potential remedial technologies within the ground water treatment category

  - Physical
  - Chemical
  - Biological

- Potential process options within the ground water chemical treatment technology type

  - Neutralization
  - Precipitation

- Ion exchange
- Oxidation
- Chemical reduction.

The identified technologies and process options may not all be suitable for use at the 100-KR-4 operable unit. First, the identified options are evaluated for technical implementation. This is determined by comparing the capabilities of each process option to the physical and chemical characteristics of the operable unit. Sometimes, an entire technology is eliminated because its process options are not technically implementable. The rationale for screening each remedial technology will be documented.

5.2.2.4 Subtask 2d--Evaluation of Process Options. Once identified options are evaluated for technical implementation, then the second step involves a closer evaluation of the process options associated with each remaining technology. Process options will be evaluated on the basis of effectiveness, implementability, and cost.

The effectiveness evaluation will focus on the following items:

- The potential effectiveness of the process options in handling the estimated areas or volumes of the contaminated medium and attaining the remedial action objectives for that medium
- The effectiveness of the process options in protecting human health and the environment during remedy construction and implementation
- The proven performance and reliability of the process option in respect to the contaminants and conditions at the 100-KR-4 operable unit.

Both technical and institutional implementability are considered in evaluating process options. Technical implementability will eliminate those options that are clearly ineffective or unworkable at the 100-KR-4 operable unit. Institutional considerations include the ability to obtain necessary permits for any offsite actions, the ability to meet substantive requirements of relevant permits for onsite actions, the availability and capacity of appropriate treatment, storage, and disposal services, and the availability of essential equipment and skilled labor.

Cost will be an evaluation criterion. Relative capital, operations and maintenance costs, as opposed to detailed estimates, will be determined based on engineering judgement. Processes within the same technology type will be compared with respect to cost.

Innovative technologies may by applicable at the 100-KR-4 operable unit. Should an innovative technology offer the potential for comparable or superior performance or implementability or exhibit fewer or less adverse environmental impacts, better treatment, or lower costs over a conventional demonstrated treatment technology, then it could progress through the screening process.

Applicable technologies with one or more feasible process options will be used in developing remedial alternatives. Multiple process options based on one technology may be combined into a given remedial alternative. Process options that are not selected for development, generally will not be considered later in the FS. They may, however, be reinvestigated during remedial design if the associated technology is selected for implementation at the 100-KR-4 operable unit.

5.2.2.5 Subtask 2e--Assembly of Remedial Alternatives. Preliminary remedial alternatives will be developed for each contaminated environmental medium of concern. This will involve assembling medium-specific process options or possibly remedial technologies or general response actions. The four types of environmental media discussed in Section 5.3.2.1 can be remediated using one of two methods: (1) develop alternatives for the entire operable unit or (2) screen medium-specific alternatives first (Section 5.5) to reduce the alternatives for the entire operable unit. Both methods are consistent with EPA's interim final RI/FS guidance (EPA 1988a). The chosen method will be discussed with EPA before undertaking this task.

Several waste solutions are available for remediation of the site. They include the following:

- A no-action alternative
- Treatment alternatives ranging from treating wastes before on site storage to eliminate the need for long-term management
- Management alternatives for onsite and offsite waste containment and storage.

Section 121(b)(1) of CERCLA has a statutory preference for permanent and significant waste treatment. Containment and treatment alternatives will be developed in conjunction with the selection of treatment technologies. This is more acceptable than waste removal and offsite disposal alternatives.

5.2.2.6 Subtask 2f--Action-Specific Requirement Identification. The preliminary action-specific remedial action requirements, which were identified in Section 3.2.2, will be reexamined after the technology alternatives have been examined to eliminate options that are not desirable or feasible. Special consideration will be given to the regulations that may influence the treatment (or exemption from treatment) of water containing tritium because of the lack of treatment options.

5.2.2.7 Subtask 2g--Evaluation of Data Needs. In the process of developing remedial alternatives, additional RI data needs may be identified. An assessment will be made concerning their value in the 100-KR-4 operable unit conceptual model or alternative evaluation criteria. Any uncertain data needs will be discussed in the detailed analysis of alternatives (Section 5.5) and may be evaluated in a sensitivity analysis. Other data needs may require additional characterization or treatability studies.

5.2.2.8 Subtask 2h--FS Report Phase I - Remedial Alternatives Development. The Phase I feasibility study report will document the results of the identification and screening of remedial technologies and the development of remedial alternatives. Examples of the types of information to be included in the 100-KR-4 operable unit FS report are as follows:

- Operable unit background summary with available project scoping information and any initial RI data, to include the nature and extent of contamination and contaminant fate and transport
- Confirmation of the operable unit environmental media of concern; include the rationale for continued inclusion in the FS
- Identification of the preliminary remedial action objectives for each environmental medium of concern
- Identification of the general response actions for each environmental medium of concern
- Identification of potential remedial technology types for each medium-specific general response action category
- Documentation of the screening process for technical implementability of remedial technology types
- Identification of potential technological process options for each technology type retained
- Documentation of the process options evaluation process and the selection of representative process options for each technology type
- Documentation of the assembly of general response actions, process options, and technologies into a range of remedial action
- Identification of action-specific ARARs potentially pertinent to each alternative
- Identification of any new data needs for the RI Phase II.

5.2.3 Task 3--FS Phase II - Remedial Alternatives Screening

The screening of remedial alternatives follows the development of the alternatives and precedes analysis of the alternatives. The objective of screening the alternatives is to reduce the list of potential remedial actions to a manageable level. The potential remedial actions will be evaluated in greater detail, based on effectiveness, implementability, and cost.

The major steps to be performed during the screening process are as follows:

- Refine remedial action objectives
- Refine remedial alternatives

- Evaluate the refined alternatives on a general basis to determine effectiveness, implementability, and cost.

The alternatives that meet the remedial action objectives are then retained for detailed analysis in Phase III of the FS.

The following is a summary of the Phase II FS process. Further details can be found in the draft EPA RI/FS guidance (EPA 1988a).

5.2.3.1 Subtask 3a--Refinement of Remedial Action Objectives. The remedial action objectives developed in Phase I of the FS for each environmental medium of interest will be refined based on the information gathered during the RI. Exposures may occur through multiple pathways and may involve interactions among environmental media. Refinement of the remedial action objectives will ensure protection of human health and the environment from all potential pathways of concern at the operable unit.

Evaluation of media interactions will determine whether or not ongoing releases significantly affect contaminant levels in other media, such as soil to ground water. Media that do not pose a significant risk to human health and the environment may be identified. The RI Phase I information will be used to refine remedial action objectives to better fit the project site and to allow for nearly developed remedial technologies.

5.2.3.2 Subtask 3b--Definition of Remedial Action Alternatives. The remedial action alternatives developed in Phase I of the FS will be further defined to identify details of process options, process sizing requirements, remedial time frames, and the refined remedial action objectives.

RI Phase I information will more accurately identify the extent of contamination so that suitable equipment, technologies, and process options can be evaluated.

The specific types of information that will be developed under this task for the remedial technologies and process options used in each alternative will be as follows:

- Size and configuration of onsite removal and treatment systems
- Identification of contaminants that impose the most demanding treatment requirements
- Size and configuration of containment structures
- Time frame in which treatment, containment, or removal goals can be achieved
- Treatment rates or flow rates associated with treatment processes
- Special requirements for construction of treatment or containment structures, staging construction materials, or excavation
- Distances for disposal facilities

- Required permits and imposed limitations.

All information and assumptions used in generating this information will be thoroughly documented.

5.2.3.3 Subtask 3c--Screening of Alternatives. The remedial alternatives will be screened with regard to the short- and long-term aspects of effectiveness, implementability, and cost. Innovative alternatives will be evaluated and similar alternatives will be compared. The most promising alternatives will be carried forward for further analysis, and then distinctions across the entire range of alternatives will be made.

Alternatives will be retained that have the most favorable composite evaluation. The selections, to the extent practicable, will preserve the range of appropriate remedial alternatives. Ten or fewer alternatives that address the entire operable unit are expected to be retained. Additional alternatives may be needed if disposal alternatives, rather than operable unit-specific alternatives, are developed and preferred. Unselected alternatives may be reconsidered if new information shows additional advantages.

5.2.3.3.1 Effectiveness Evaluation. Each alternative will be evaluated on the basis of its protection to human health and the environment through reductions in toxicity, mobility, or waste volume. Short-term protection needed during the construction and operation period, and long-term protection needed after completion of the remedial alternative, will be evaluated. Sensitivity analyses will be made to evaluate performance.

Residual contaminant levels remaining after a reduction of waste toxicity, mobility, or volume will be compared to contaminant-specific ARARs, pertinent TBC values, and levels established through risk assessment calculations.

5.2.3.3.2 Implementability Evaluation. Implementability is the measure of both the technical and institutional feasibility of accomplishing an operable unit remedial alternative. Technical feasibility refers to the ability to construct, operate, meet action-specific ARARs, and maintain and monitor the remedial technologies or process options. Institutional feasibility refers to the ability to obtain approvals from appropriate agencies and to procure required services, equipment, and personnel.

Alternatives deemed technically unfeasible will be dropped from consideration. The only reason an institutionally unfeasible alternative will not be dropped is lack of agency approval. In this situation, the remedial alternative will be retained, if possible, with the incorporation of appropriate coordination steps needed to lessen its negative aspects.

5.2.3.3.3 Cost Evaluation. Comparative cost estimates will be made. Cost estimates will be based on cost curves, generic unit costs, vendor information, conventional cost-estimating guides, and previous similar estimates. Both capital costs and operating and maintenance costs will be considered where appropriate. Present worth analyses will be used to evaluate expenditures that occur over different time periods, so that costs for different remedial alternatives can be compared on the basis of a single figure for each.

5.2.3.3.4 Evaluation of Innovative Alternatives. Innovative technologies will be considered if they are fully developed but lack sufficient cost or performance data for routine use at CERCLA sites. It is unlikely that alternatives that incorporate innovative technologies will be evaluated as thoroughly as is done with available technologies. However, innovative technologies will pass through the screening phase if they meet the criteria. The need for treatability studies on retained innovative technologies will be made in conjunction with subtask 3e.

5.2.3.4 Subtask 3d--Verification of Action-Specific Applicable or Relevant and Appropriate Requirements. Identification of action-specific ARARs will be made easier by the new information gathered on technologies and configurations during the screening process. The list of potential ARARs previously identified will be refined by project staff with input from Ecology and EPA. Regulatory agency participation will provide project focus and direction, and will expedite the FS Phase I/II report review produced under Task 4.

5.2.3.5 Subtask 3e--Reevaluation of Data Needs. During the RI Phase II, treatability testing will be conducted on the remaining alternatives. Additional site characterization data needs may develop during the screening phase, which would necessitate additional field investigations. The work would then focus on a more thorough explanation of the effect of operable unit conditions or the performance of the remedial measure technologies and process options of greatest interest. The effectiveness of performance will be evaluated using sensitivity analysis. Data quality objectives will be refined or developed, as needed, for any additional investigations.

5.2.4 Task 4--Feasibility Study Phase I/II Report: Remedial Alternatives Development

The objective of Task 4 is to evaluate the impact of 100-K Area facilities on the shoreline of the Columbia River in the area, and on river water quality. The investigation will compile and interpret existing data on sediment and water quality in the area; collect new data to fill in gaps; and interpret the results of the field program relative to a risk assessment and selection of appropriate remedial actions if required.

The investigation is designed to obtain field data that will reveal whether or not residual contamination from past operations in the 100-K Area is detectable in: (1) ground water seepage from the riverbanks; (2) sediments along the river shoreline; and (3) river water adjacent to any seeps that show elevated levels of 100-K Area contamination indicators. Sampling in these three environments will have the greatest probability of identifying contamination zones attributable to 100-K Area, or preferred pathways for ground water discharge to the Columbia River. However, quantitative data from this sampling may not provide conservative estimates of total discharge into the Columbia River from ground water, because dilution by river water takes place at the interface between saturated sediment and river water.

Monitoring wells located near the Columbia River will provide information on what is migrating towards the river with ground water, and these data can be used as a conservative estimator of what is potentially discharging into the Columbia River, either via seepage along the riverbanks or through riverbed sediment. Water quality measurements, radiation surveys, and biota sampling, which are conducted as part of the Hanford Environmental Surveillance Program, will be used in conjunction with the data obtained through field surveys for the 100-KR-4 operable unit, to interpret the public health and safety risk associated with the shoreline along the 100-K Area.

Actual measurement of contaminated ground water seepage into the Columbia River through the riverbed would be difficult without specially constructed equipment. The problem is to trap a sample of saturated sediment, with either a grab or core-type sampler, and then isolate it from dilution with river water as it is returned to the surface. An alternative method may involve equipment that could obtain an in situ sample of sediment pore water. While highly desirable to obtain such samples as part of an overall assessment of the impact Hanford Site contaminants have on the Columbia River system, the work is more appropriately conducted under a separate research program. Collecting grab samples for the purpose of analyzing particulates only does not suffer from this difficulty.

Particulate contamination was discharged directly into the Columbia River through riverbed outfalls during the reactor operating period (see Section 3.1.4.4). It is possible that some of that material remains in depositional areas in the immediate vicinity of the outfall; some of it is known to have accumulated in downstream depositional areas such as McNary Dam (Jaquish and Bryce 1989). A reconnaissance sediment sampling program will be conducted to determine the distribution of radionuclide contamination in the vicinity of the outfall.

It is likely that contaminants from sources other than 100-K Area facilities are present in both Columbia River water and sedimentary deposits, where particulate contamination from an upstream source may be concentrated by the natural depositional processes of the Columbia River. As a result, the field sampling proposed in this task may identify zones of contamination along 100-K Area shoreline that are not products of 100-K Area operations. Regardless of the source, the concentrations and rates of discharge will be determined and used to assess the risk of public exposure as part of the 100-KR-4 operable unit.

River level data will be collected simultaneously with water level measurements in monitoring wells, to better understand the interface between ground water migrating towards the Columbia River and the influx of river water to the banks during high river levels. Similar efforts are already in progress at both the 100-H and 300 Areas, as part of RCRA monitoring projects. The mixing process apparently dilutes ground water with river water, before ground water seeps into the Columbia River (Peterson 1990). Fluctuating ground water levels may also be involved in remobilizing contamination stored in the soil column as a result of past disposal practices. Similar processes are likely to be occurring in the 100-K Area.

The surface water and sediment investigation will be coordinated with similar investigations at other shoreline operable units (e.g., 100-NR-1, 100-HR-3, 100-FR-1, and 300-FF-5) and with sample collection and radiation surveys that are conducted as part of the Hanford Environmental Surveillance Program (e.g., Jaquish and Bryce 1989). Coordination will be established to ensure sampling protocols that produce comparable data; complementary schedules and sampling locations; and exchange of interpretive results as quickly as possible.

5.2.4.1 Subtask 4a--Report Preparation. The results of the initial screening of alternatives will be combined with the interim FS Phase I report, and any significant comments will be contained in that report. This information will help develop a document summarizing both the development and screening of alternatives for the operable unit. The report will list the procedures for evaluating, defining, and screening the alternatives. The following types of information pertinent to the screening phase will also be included:

- Refined remedial action goals associated with each alternative, including any modifications made to ensure that multiple-pathway exposures and medium interactions are addressed
- Definition of each alternative, including extent of remediation, area or volume of contaminated media, sizes of major technologies, process parameters, cleanup time frames, transportation distances, and special considerations
- Screening evaluation summaries of each alternative process
- A comparison of screening evaluation among alternatives.

A reevaluation of data needs for the RI Phase II will be included in this report. Details of the FS Phase I/II report will, in turn, be summarized in the final FS report.

5.2.4.2 Subtask 4b--Report Review and Approval. The FS Phase I/II report will be subject to internal peer review before being forwarded to regulatory agencies. As a primary document, the report will be reviewed and approved by EPA and Ecology.

5.3 OPERABLE UNIT CHARACTERIZATION AND TREATABILITY INVESTIGATION

5.3.1 Tasks 1 Through 8--Operable Unit Characterization

Any or all of the operable unit characterization tasks (1 through 8) as identified in Section 5.1 may need to have supplemental data.

Additional data needs essential to evaluating alternatives may be identified as operable unit information is collected during the RI Phase I and FS Phase I and II. In response to these needs, site characterization data may need to be collected or treatability studies performed to better evaluate certain remedial action technologies.

Some of the technologies selected for detailed analysis at the 100-KR-4 operable unit may be well developed, proven, and documented. Should this be the case, then unit-specific information collected during the RI Phase I should be adequate for evaluation without conducting treatability testing. However, for untested technologies, it is impossible to predict treatment performance or to estimate the size and cost of treatment units. Some treatment processes, particularly innovative technologies, are not sufficiently understood to predict performance, even with complete waste characterization.

When treatment performance is difficult to predict, either bench-scale or pilot-scale testing may provide the most cost-effective means of obtaining the necessary process performance data. At the Hanford Site, some treatability investigations may be performed on a site-wide basis, rather than on an operable unit-specific basis. Any Hanford Site-wide treatability investigation results that are relevant to the 100-KR-4 operable unit and completed in time to be applied to the operable unit will be incorporated into the project.

The primary purposes of the treatability investigation, in accordance with the EPA's interim final RI/FS guidance document (EPA 1988a), are to provide sufficient technology performance information and to reduce cost and performance uncertainties to acceptable levels, so that treatment alternatives can be fully developed and evaluated during detailed analysis. Secondarily, the treatability investigation may generate useful information for conducting the detailed design of a treatment remedy if the particular treatment technology is a component of the selected remedial action alternative. The allocation of time for a potential treatability investigation also provides a mechanism to conduct further site characterization activities.

The need for any treatability investigation or additional characterization of the 100-KR-4 operable unit will be identified once remedial alternatives are developed. If and when the need arises for a treatability investigation, the 100-KR-4 operable unit work plan will be amended to provide detailed RI Phase II activities, to provide accompanying volumes of the RI/FS project plans, and to provide guidance for the required work before implementation. The RI/FS Phase I report will give formal, interim evaluations of further data needs, in terms of treatability investigation. Responsibility for this task rests with the unit managers for the project.

5.3.2 Task 9--Treatability Investigation Work Plan Development

Once treatability tests have been identified, the 100-KR-4 operable unit work plan will be updated to include the treatability investigations. The work plan will identify the treatability tests needed, the additional site characterization data needed, and any site samples and other test materials and equipment needed to conduct the tests. A schedule will be prepared for obtaining all necessary site characterization data, samples, test materials, equipment, analytical services, and permits.

Following approval of the 100-KR-4 operable unit work plan, individual treatability investigation work plans will be prepared for each technology to be tested. The development of each work plan will involve the following steps:

- Determine the scale of the test
- Identify parameters needed and evaluate the treatment viability of the technology
- Determine specifications for test samples and sample procurement
- Determine the test equipment, materials, and procedures to be used in the treatability test
- Identify where and by whom the tests and any analytical services will be conducted; identify any special procedures and permits required to transport samples and residues; conduct tests
- Identify the methods required for residue management and disposal
- Identify any special QA/QC needed for the tests
- Identify any special safety training or procedures needed for the tests.

Determining the scale of the test is the first step in developing an individual treatability investigation work plan for a specific technology, because it has a major influence on the cost, schedule, and complexity of the test. Establishing the scale involves scaling the results to the expected full-scale process; finding data to design, construct, and operate the equipment at a minimum acceptable scale; and obtaining the necessary quantities of site materials for the test. For most treatment technologies, bench-scale tests will be sufficient to obtain the data necessary to evaluate a full-scale process. However, some technologies (e.g., in situ treatment technologies and containment or barriers technologies), may require pilot-scale tests to obtain the data needed to conduct a satisfactory evaluation of the technology. Furthermore, if insufficient data are available to design the pilot test, then bench-scale tests will have to be conducted first. The scale of the test will also be influenced by the difficulty in obtaining the sample volume necessary for conducting the test.

The range of each key parameter that will be evaluated in the tests will be specified. Some of these parameters, such as pH or temperature, will be varied over a range determined by site characteristics and the effects of any pretreatment steps. In addition, key performance criteria such as contaminant removal efficiency or leaching rate will be established in the test plan. For example, to prepare samples for testing in a precipitation and coagulation process for removing chromium from water, it is conceivable that uncontaminated ground water could be spiked with varying quantities of hexavalent chromium and principal dissolved solids, such as calcium or sulfate, as necessary to cover the specified test range. However, an ion exchange process may need actual waste water for valid treatability testing.

The equipment, materials, and test procedures will be specified for each individual treatability investigation as required to obtain the necessary data. In determining what equipment and test procedures are required, particular attention will be given to those identified in a literature survey. The equipment and procedures will also be consistent with approved EPA testing methods. Particular attention will be given to the methods and accuracy required for measuring key performance variables, such as effluent contaminant concentration, to ensure that the sensitivity of the analytical methods and equipment match the sensitivity required to compare results to the test criteria.

Two important considerations in developing each individual plan are where and by whom the tests will be conducted. If the test is to be conducted offsite or at the 100-K Area, special permits may be necessary for constructing and operating equipment or for transporting wastes and residues offsite. Similarly, when the work is conducted by a subcontractor, equipment, test, and sample analyses will need to be negotiated with respect to the treatability investigation work plan.

Management and disposal requirements for residues produced during the test will be determined. The quantity, composition, and location of the waste may influence treatability test plans. Management of the residues may be an important consideration in determining where and at what scale the tests are to be conducted.

The QA/QC plans will be reviewed to determine any special quality-related requirements necessary for each individual treatability investigation. Special consideration will be given to the capability to detect and reliably measure contaminants at the concentrations required by the criteria, as well as the potential for contamination of samples during collection, storage, and analysis.

The HSPs will be reviewed to determine whether any special training or procedures will be needed. Health and safety considerations will be given to both waste-handling and test operations.

A separate plan will be prepared for each individual treatability investigation and will provide the detail necessary for conducting the tests. Each plan will include the following sections:

- Project description and site background
- Remediation technology description
- Test goals
- Description of equipment and materials
- Test procedures
- Test plan for parameters to be tested
- Sampling plan

- Analytical methods
- Data management
- Data analysis and interpretation
- Reporting of results
- Health and safety
- Quality assurance
- Residuals management
- Schedule
- Test sample disposal.

Each of these sections will incorporate information developed during previous activities, as described above.

5.3.2.1 Treatability Investigation. Treatability testing can be performed by using either bench-scale or pilot-scale studies. As noted previously, a literature survey will be undertaken to identify specific data needs for the treatability investigation. The objectives of such a survey are as follows:

- Determine whether the performances of treatment technologies under consideration have been sufficiently documented on similar wastes, taking into consideration the scale of such documentation (e.g., bench-, pilot-, or full-scale)
- Determine the number of times the treatment technologies have been successfully used
- Gather information on relative costs, applicability, removal efficiencies, operations and maintenance requirements, and implementability of the candidate treatment technologies
- Determine specific testing requirements and appropriate scale for any required treatability tests.

Treatability studies will include the following steps:

- Preparation, review, and approval of a treatability investigation work plan for the bench or pilot-scale studies
- Performance of the bench or pilot-scale testing
- Evaluation of data from bench or pilot-scale testing
- Incorporation of the results of the testing into the final RI report.

5.3.2.2 Update of RI/FS Work Plans. The information gathered during the treatability investigation will be used to update this work plan. The work plan will include a description of the technology, background site information relevant to each technology requiring a treatability investigation, and documentation of missing data. The plan will contain the following information:

- Project description and site background
- Summary of individual treatability tests
- Schedule
- Cost.

The project description and site background section will summarize appropriate information on site characteristics, contaminant levels, allowable levels, and the remedial action alternatives that are relevant to the technologies being investigated in the treatability investigation. The section summarizing treatability tests will contain brief descriptions of each test, including the approximate scale of the test (bench- or pilot-scale), and whether there are any special requirements for the test that could impact the overall schedule for the work plan.

5.3.3 Task 10--Treatability Investigation Work Plan Implementation

This task is the implementation of the treatability investigations. This task will also include any related data evaluation activities that are needed. Specific needs of the RI Phase II will depend on the data gaps identified as part of the data evaluation process.

Bench-scale (laboratory) testing may be used to provide information to determine the feasibility of waste treatment or destruction technologies, although care must be taken in extrapolating laboratory data to full-scale performance. Bench-scale tests can be used to evaluate a wide variety of operating conditions and to determine broad operating conditions to allow optimization during additional bench- or pilot-scale tests. Bench-scale testing is usually a relatively fast and low-cost process.

Potential objectives of bench-scale testing are to make the following determinations:

- Effectiveness of the treatment technology on wastes
- Differences in performance between competing manufacturers
- Differences in performance between alternative chemicals used in the treatment process
- Sizing requirements for any pilot-scale studies
- Potential technologies to be pilot tested

- Sizing of those treatment units that would affect the technology cost sufficiently to affect the detailed analysis of remedial alternatives

- Compatibility of process materials with wastes of the 100-KR-4 operable unit.

Before initiating bench-scale treatability tests, the following information will be collected or developed:

- Waste sampling plan

- Waste characterization information, which will be available from RI Phase I data

- Treatment goals, which will be available from remedial action objectives and action-specific ARARs

- Data requirements for estimating the technology cost within -30 to +50% accuracy

- Required test services, equipment, chemicals, and analytical services

- Method of disposal for sampled material.

For a technology that is well developed and tested, bench-scale studies are usually sufficient to evaluate performance on new wastes.

A pilot-scale test, as compared to a bench-scale test, is intended to more accurately simulate the operations of a full-scale process; however, pilot-scale tests require significant time and can be quite costly. Therefore, the need for pilot-scale testing must be determined by balancing the data need against the additional time or money for the test. Pilot-scale testing is often appropriate for innovative technologies, and such testing will be considered if it offers potential significant savings in time or money required for an alternative to achieve remedial action objectives.

Before the initiation of any pilot-scale testing, the following information, in addition to the items mentioned above concerning bench-scale testing, will be collected or developed:

- Operable unit-specific information impacting test requirements, including waste characteristics, facility characteristics, availability of services and equipment

- Waste requirements for testing; volumes, need for any pretreatment, handling, transport, and disposal

- Specific data requirements for technologies to be tested.

Recommended formats for bench-scale and pilot-scale treatability investigation work plans, along with additional details on the process, can be found in EPA's interim final RI/FS guidance document (EPA 1988a).

5.3.4 Task 11--Data Evaluation

This task is reserved for the evaluation of any data generated during the treatability investigation, if implemented. The specific components and goals of this task will depend on the data needs of the Phase II RI. Thus, the details for this task will be described at the time any treatability investigation work plan is developed under Task 1.

5.3.5 Task 12--Baseline Risk Assessment

The objective of the baseline risk assessment task is to determine the magnitude and probability of potential harm to human health or the environment by the threatened or actual release of a hazardous substance from a waste site in absence of remedial action. Results of risk assessment are used to determine whether or not remedial action is necessary and to justify the remedial actions. A more detailed description of performing a risk assessment is provided in EPA (1989b).

To achieve this objective, the following areas will be identified and characterized:

- Quantity and concentrations of hazardous substances present in air, soil, ground water, surface water, sediment, and biota
- Environmental fate and transport mechanisms within specified environmental media, such as physical, chemical, and biological degradation processes and geohydrologic conditions
- Potential exposure pathways and extent of actual or expected exposure
- Potential human and environmental receptors
- Extent of expected impacts or threats, and the potential for such impacts or threats occurring (i.e., risk characterization)
- Acceptable levels of exposure based on regulatory and toxicological information.

The risk assessment process is composed of the following components that, collectively, address the areas identified:

- Contaminant identification
- Exposure assessment
- Toxicity assessment
- Risk characterization.

5.3.6 Task 13--Remedial Investigation Phase II Report

The treatability investigation report will describe the testing performed, the results of the tests, and an interpretation of how the results will affect the evaluation of the remedial action alternatives considered for the 100-KR-4 operable unit. The report will contain a discussion of the effectiveness of the tested treatment technology for the onsite wastes and an evaluation of how test results affect treatment costs developed during the detailed analysis of alternatives. These results will be combined with the site characterization results, including the results of any further activities carried out under the RI Phase II, and will be published as the final report documenting all RI activities for the 100-KR-4 operable unit.

5.4 FEASIBILITY STUDY PHASE III - REMEDIAL ALTERNATIVES ANALYSIS

The detailed analysis of remedial alternatives follows the development and screening of alternatives and precedes the actual selection of the remedial action to be implemented at the operable unit. The results of the detailed analysis provide the basis for identifying a preferred alternative and preparing the operable unit proposed plan and ROD. The detailed analysis of alternatives consists of the following components:

- Further definition of each alternative, if appropriate, with respect to the volumes or areas of contaminated environmental media to be addressed, the technologies to be used, and any performance requirements associated with those technologies
- An assessment and a summary of each alternative against evaluation criteria specified in the EPA interim final RI/FS guidance document (EPA 1988a)
- Comparative analysis among each of the alternatives that will facilitate the selection of an operable unit remedial action.

The brief summary of the detailed analysis process presented below is derived from the EPA interim final RI/FS guidance document (EPA 1988a).

5.4.1 Task 1--Definition of Remedial Alternatives

The remedial alternatives that remain after initial screening may need to be defined more completely before the detailed analysis. During the detailed analysis, each alternative will be reviewed to determine whether additional definition is required to apply the evaluation criteria consistently and to develop order-of-magnitude cost estimates (-30 to +50%). Information developed to further define alternatives at this stage may include preliminary design calculations, process flow diagrams, sizing of key process components, preliminary layouts, and a discussion of limitations, assumptions, and uncertainties concerning each alternative. Information collected from treatability investigations, if conducted, will also be used to further define applicable alternatives.

5.4.2 Task 2--Detailed Analysis of Alternatives

Nine evaluation criteria will serve as the basis for conducting the detailed analysis and for subsequent selection of a cost-effective and protective corrective measure. The nine evaluation criteria are the following:

- Overall protection of human health and the environment
- Compliance with ARARs
- Short-term effectiveness
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume
- Implementability
- Cost
- Community
- Support agency acceptance.

These criteria encompass technical, cost, and institutional considerations, compliance with specific promulgated requirements, and environmental and health protection.

The last two criteria will be addressed in the responsiveness summary and ROD documents following the FS report and the proposed plan.

5.4.2.1 Short-Term Effectiveness Analysis. This evaluation criterion addresses the effects of the alternative during the construction and implementation before remedial action objectives being attained. The following factors relating to effects on human health and the environment will be addressed for each alternative:

- Protection of the community during construction and implementation
- Protection of workers during construction and implementation
- Environmental impacts during construction and implementation
- Time until remedial action objectives are achieved.

The evaluation of these factors will include a discussion of any increased risks posed by the subject remedial alternative and an evaluation of the effectiveness and reliability of protective measures that may be taken for any needed worker protection or environmental impact mitigation.

5.4.2.2 Long-Term Effectiveness Analysis. This criterion will address the results of a potential remedial action in terms of any risk that would remain at the operable unit after remedial action objectives have been met. The following components will be addressed to evaluate the extent and effectiveness of controls that may be required to manage residual or untreated wastes:

- Magnitude of remaining risk
- Adequacy of controls
- Reliability of controls.

The evaluation of these components will include an assessment of residual risk, the adequacy of containment systems, long-term environmental monitoring networks, institutional controls, and the potential need to replace components of the remedial alternative.

5.5.2.3 Subtask 2c--Analysis of Reduction in Waste Toxicity, Mobility, and Volume. This evaluation criterion addresses the statutory preference for selecting remedies that employ treatment technologies that permanently and significantly reduce toxicity, mobility, or volume of a hazardous substance as their principal element [CERCLA 121(b)(1)]. The following specific factors will be addressed:

- Treatment processes, the remedies they will employ, and the materials they will treat
- Amount of hazardous materials that will be destroyed or treated
- Degree of expected reduction in toxicity, mobility, or volume as a percentage
- Degree to which treatment will be irreversible
- Type and quantity of treatment residuals that will remain.

Alternatives that treat an operable unit through destruction of toxic contaminants, reduction of the total mass of toxic contaminants, irreversible reduction in contaminant mobility, or reduction of total volumes of contaminated media will be deemed to satisfy the preference for permanent treatment.

5.4.2.4 Implementability Analysis. The implementability criterion addresses the technical and institutional feasibility of implementing an alternative, compliance with ARARs, and the availability of various services and materials required during its implementation as outlined in Section 5.3.3.3.2.

5.4.2.5 Cost Analysis. Costing procedures outlined in the *Remedial Action Costing Procedures Manual 4* (EPA 1985) will be used in this analysis. Both capital costs and annual operation and maintenance costs will be considered. Costs will be developed within accuracy of -30 to +50%. In addition, a present worth analysis will be conducted so that all alternatives can be compared on the basis of a single figure in a common base year. A discount rate of 5% will be used for a period of performance of 30 yr.

5.4.2.6 Analysis of Overall Protection of Human Health and the Environment. This evaluation criterion provides a final check to assess whether or not each alternative meets the statutory requirement that it be protective of human health and the environment [CERCLA 121(d)(1)]. The overall assessment of protection is based on a composite of factors discussed under long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs. The analysis will address how each specific alternative achieves protection over time and how operable unit risks are reduced. A discussion will be included of how each source of contamination is to be eliminated, reduced, or controlled for each alternative.

5.4.2.7 Analysis of Community and State Acceptance. A preliminary assessment of community and state acceptance will be limited to formal comments made in earlier phases of the RI/FS. Agency comments on the remedial alternatives analysis and proposed plan will be specifically addressed in a responsiveness summary before the selection of the remedial action and ROD development. The potentially impacted community, special interest groups, the general public, and other interested governmental agencies will have an opportunity to review and comment on the FS report. Community concerns will also be addressed in the responsiveness summary and ROD.

5.4.3 Task 3--Comparison of Remedial Alternatives

Once the alternatives have been individually assessed against the nine criteria, a comparative analysis will be conducted to evaluate each alternative in relation to each evaluation criterion. The key tradeoffs or concerns among alternatives will generally be based on the evaluations of short-term effectiveness; long-term effectiveness and permanence; reduction of toxicity, mobility, and volume; implementability; and cost. Overall protection and compliance with ARARs serve as a threshold determination in that they either will or will not be met.

The comparative analysis will include a narrative discussion describing the strengths and weaknesses of the alternatives relative to one another with respect to each criterion. The potential advantages in cost or performance of innovative technologies and the degree of uncertainty in their expected performance will also be discussed. The differences between all of the alternatives will be summarized in matrix form to facilitate direct comparisons. The information obtained by analyzing the alternatives individually against the nine criteria in Section 5.5.2 will be the basis for the matrix.

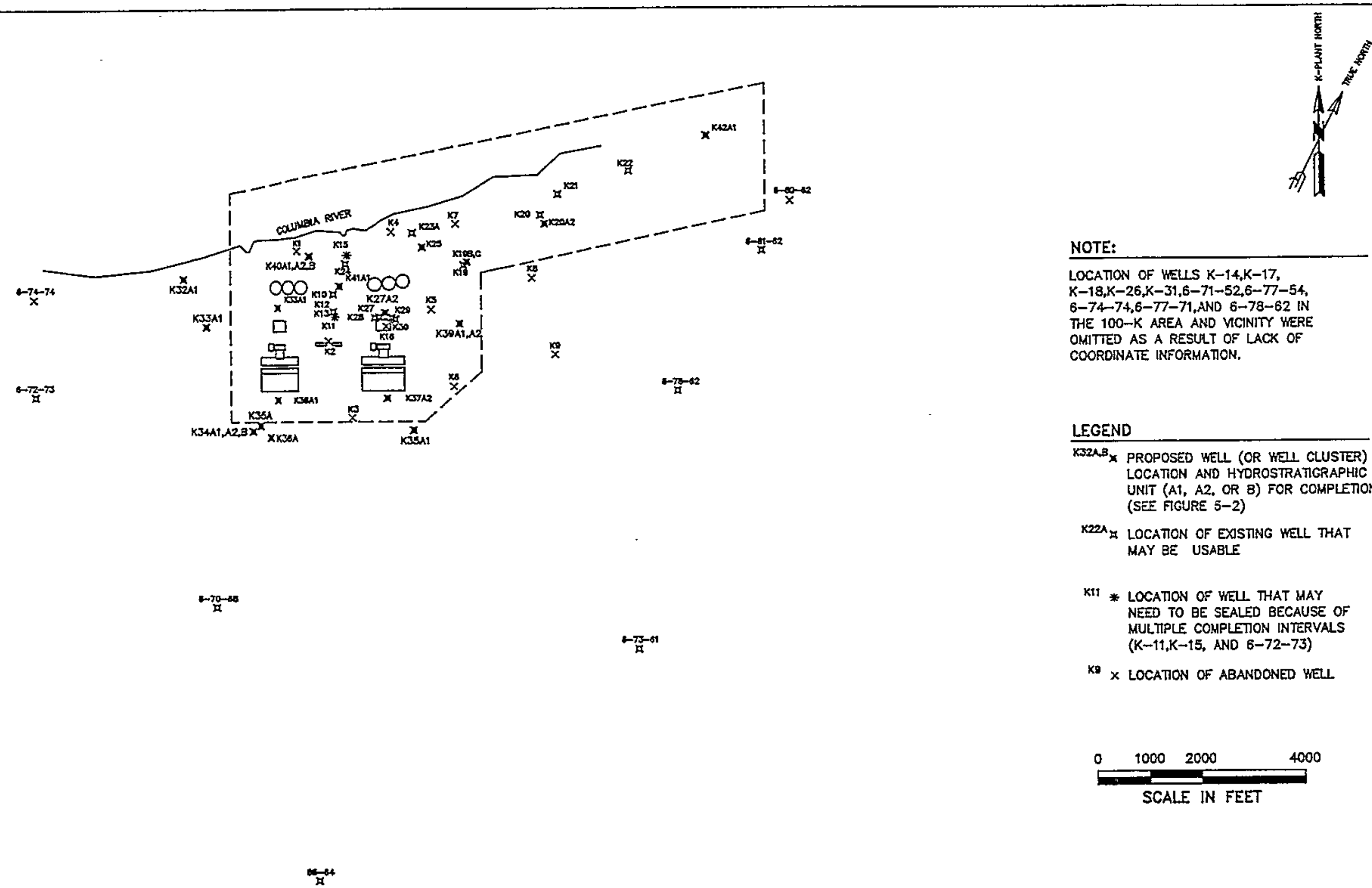
5.4.4 Task 4--Feasibility Study Report

The analysis of individual alternatives against the nine criteria will be presented as a narrative discussion accompanied by the summary matrix of Section 5.5.3. The alternatives discussion will include data on technology components, quantity of hazardous materials handled, time required for implementation, process sizing, implementation requirements, and assumptions. The key ARARs for each alternative will also be incorporated into those discussions. The discussion will focus on how, and to what extent, the various factors within each of the criteria are addressed. A summary matrix will highlight the assessment of each alternative with respect to each of the criteria.

5.4.5 Task 5--Remedial Action Plan

Based on the results of the comparison of alternatives in the FS, the preferred remedial alternative will be selected by EPA in consultation with Ecology. The preferred alternative will be developed into a proposed plan to be completed in accordance with Section 117(a) of CERCLA, Section 300.430(f)(2) of 40 CFR, and OSWER Directive 9355.3-01 (EPA 1988a). The proposed plan and FS report will be made available for public review at the same time, after regulatory approval. The proposed plan will consist of a very brief summary written for the public that discusses the nature and extent of contamination at the 100-KR-4 operable unit, the overall remediation process, the preferred alternative and its advantages and disadvantages, and the other alternatives that are fully developed and analyzed in the FS report.

Significant comments on the proposed plan will be addressed in a responsiveness summary to be prepared during the selection of the remedial action process, or ROD process, immediately following the RI/FS. The remedial selection process will then be formally documented in the ROD for the 100-KR-4 operable unit.



NOTE:

LOCATION OF WELLS K-14,K-17, K-18,K-26,K-31,6-71-52,6-77-54, 6-74-74,6-77-71,AND 6-78-62 IN THE 100-K AREA AND VICINITY WERE OMITTED AS A RESULT OF LACK OF COORDINATE INFORMATION.

LEGEND

K32A,B × PROPOSED WELL (OR WELL CLUSTER) LOCATION AND HYDROSTRATIGRAPHIC UNIT (A1, A2, OR B) FOR COMPLETION (SEE FIGURE 5-2)

K22A ¤ LOCATION OF EXISTING WELL THAT MAY BE USABLE

K11 * LOCATION OF WELL THAT MAY NEED TO BE SEALED BECAUSE OF MULTIPLE COMPLETION INTERVALS (K-11,K-15, AND 6-72-73)

K9 × LOCATION OF ABANDONED WELL

0 1000 2000 4000

SCALE IN FEET

Figure 5-1. Existing and Proposed Monitoring Well Locations.

100-KR-4

KR-1-4\901-5-1.DWG

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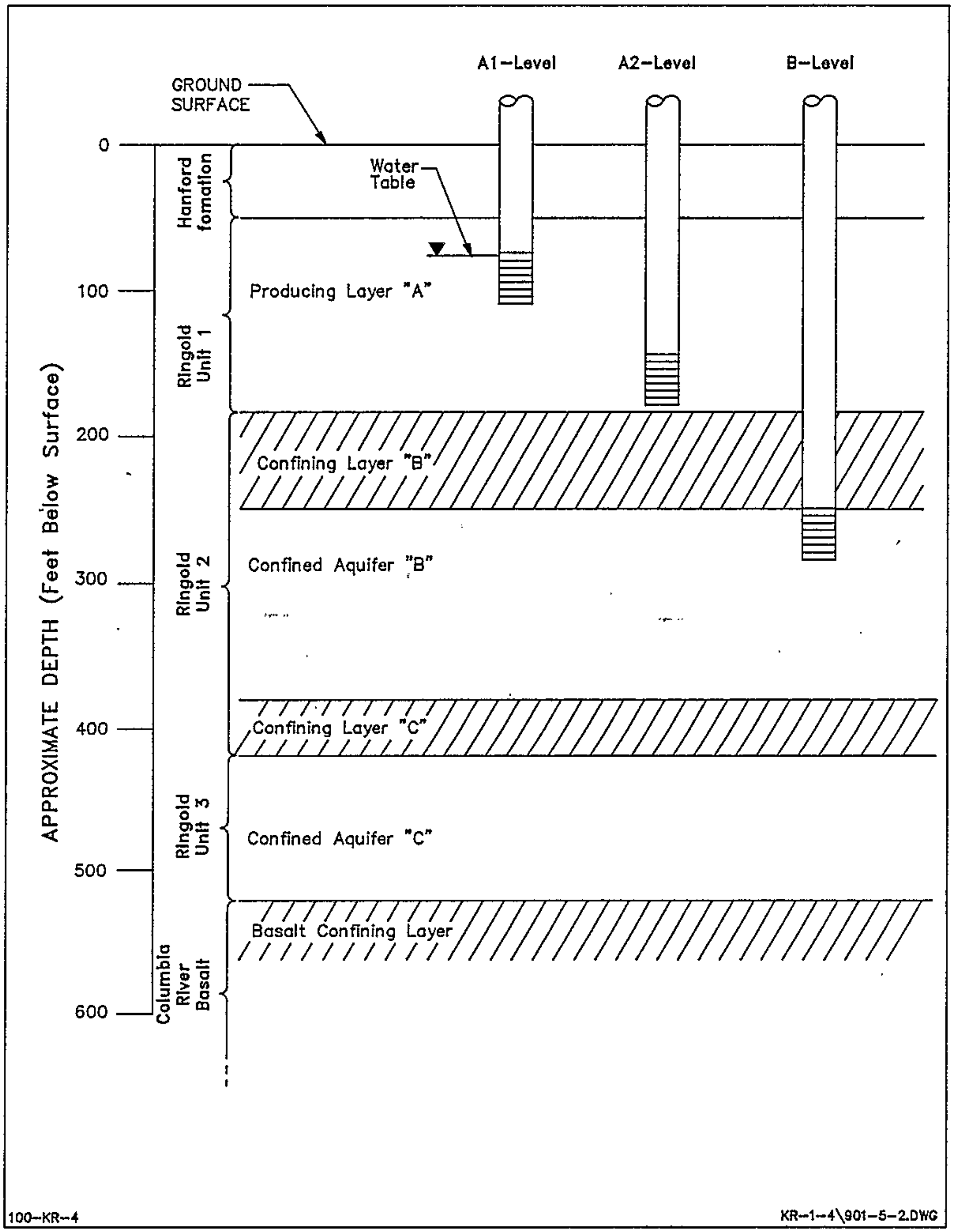

Figure 5-2. Hydrostratigraphic Zones Targeted for Monitoring Well Completions at 100-K Area.

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DATA TYPE	1-K-19A2	1-K-19B	1-K-20A2	1-K-27A2	1-K-32A1	1-K-33A1	1-K-34A1	1-K-34A2	1-K-34B	1-K-35A1	1-K-36A1	1-K-37A1	1-K-38A1	1-K-39A1	1-K-39A2	1-K-40A1	1-K-40A2	1-K-40B	1-K-41A1	1-K-42A1
TASK 3: GEOLOGIC INVESTIGATION																				
Lithology and Thickness of Vadose Zone	•		•	•	•	•	•			•	•	•	•	•		•			•	•
Lithology of Ringold Unit 1(Producing Layer A)	•		•	•	•	•	•			•	•	•	•	•		•			•	•
Thickness of Ringold Unit 1(Producing Layer A)	•		•	•				•							•		•			
Lithology and Thickness of Ringold Unit 2a (Confining Layer B)		•							•									•		
Lithology of Ringold Unit 2b (Confined Aquifer B)		•							•									•		
Lithology of Ringold Unit 2c (Confining Layer C)		•							•									•		
TASK 6: GROUND WATER INVESTIGATION																				
Vertical Gradients	•	•	•	•			•	•	•					•	•	•	•	•		
Gradients and Monitoring of Water Table (Ringold Producing Layer A)					•	•	•			•	•	•	•	•		•			•	•
Gradients and Monitoring of Lower Portion of Ringold (Producing Layer A)	•		•	•				•							•		•			
Gradients and Monitoring of Ringold Confined Aquifer B		•							•									•		
Hydraulic Conductivity	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
SOURCE SPECIFIC MONITORING																				
116-KW-3 Retention Basins																•	•	•		
118-K-3 Filter Crib																			•	
116-K-2 Trench	•	•	•																	•
West Reactor Area													•							
118-K Area														•	•					
105-KE Fuel Storage Basin				•																
120-KW Tanks											•									
120-KE Tanks												•								
Upgradient Monitoring					•	•	•	•	•	•										

Figure 5-3. Primary Rationale for New Well Locations and Depths.

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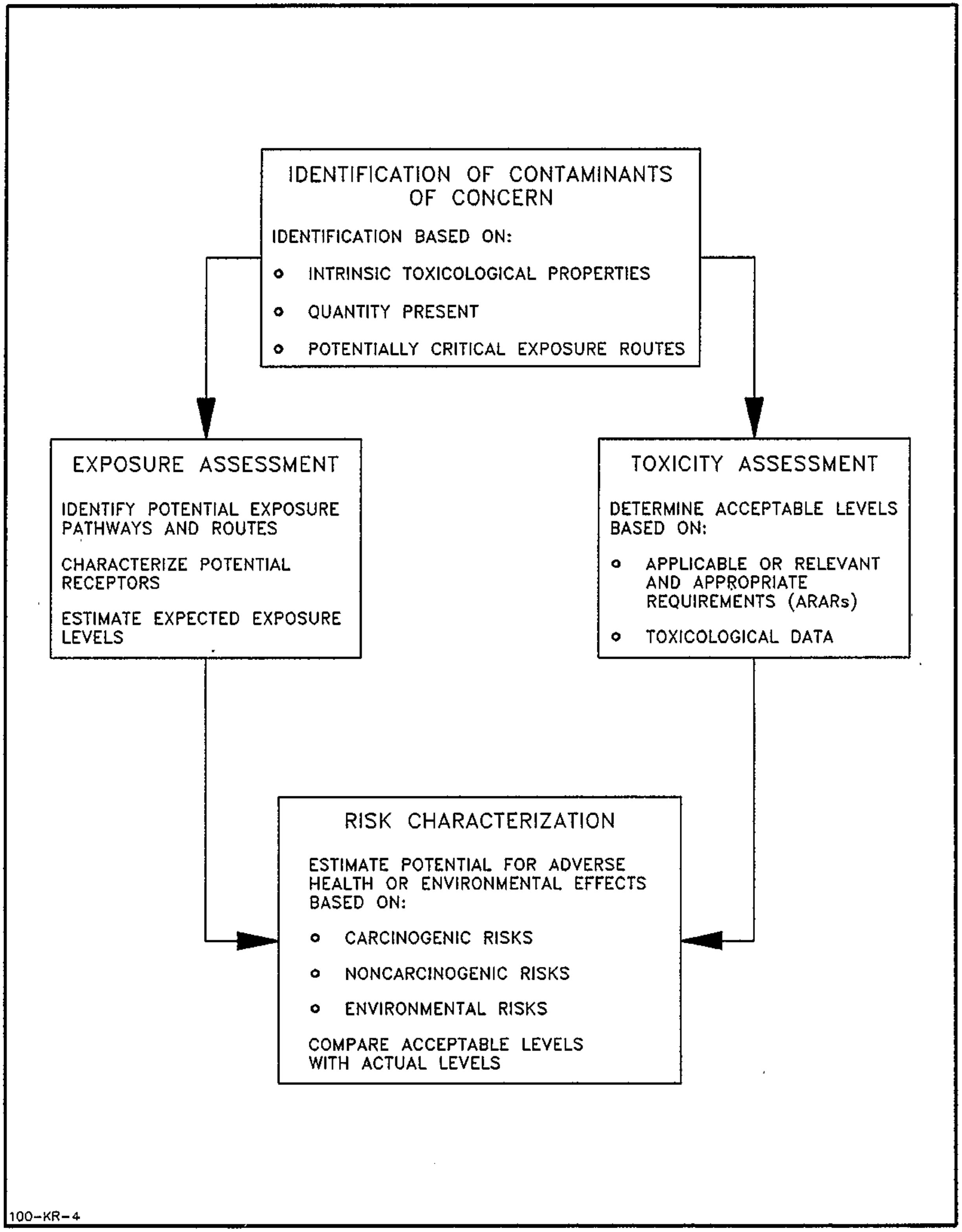

Figure 5-4. Components of the Risk Assessment Process.

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Table 5-1. Proposed Soil Chemical Analysis. (sheet 1 of 3)

Long List of Soil Chemical Analysis

General Chemical Parameters

Ammonia-N
Carbonate
Chloride
Fluoride
Nitrate
Phosphate
Sulfate
Sulfamate
Oxalate

Radionuclides

Americium-241
Carbon-14
Cobalt-60
Europium-152
Europium-154
Europium-155
Gamma scan
Gross alpha
Gross beta
Iodine-129
Nickel-63
Plutonium
Strontium-90
Technetium-99
Tritium
Uranium

Inorganics (Metals)

Aluminum
Antimony
Arsenic
Barium
Beryllium
Cadmium
Chromium, hexavalent
Chromium (total)

Inorganics (metals)

Cobalt
Copper
Cyanide

Inorganic (metals)

Iron
Lead
Magnesium
Manganese
Mercury
Nickel
Potassium
Selenium
Silver
Sodium
Thallium
Vanadium
Zinc

Volatile Organic Compounds

Chloromethane
Bromomethane
Vinyl chloride
Chloroethane
Methylene chloride
Acetone
Carbon disulfide
1,1-Dichloroethene
1,1-Dichloroethane
1,2-Dichloroethene(total)
Chloroform
1,2-Dichloroethane
2-Butanone
1,1,1-Trichloromethane
Carbon tetrachloride
Vinyl acetate
Bromodichloromethane
1,2-Dichloropropane
cis-1,3-Dichloropropane

Table 5-1. Proposed Soil Chemical Analysis. (sheet 2 of 3)

<u>Volatile Organic Compounds</u>

Trichloroethene
Dibromochloromethane
1,1,2-Trichloromethane
Benzene
trans-1,3-Dichloropropane
Bromoform
4-Methyl-2-pentanone
2-Hexanone
Tetrachloroethane
Toluene
1,1,2,2-Tetrachloroethane
Chlorobenzene
Ethyl benzene
Styrene
Xylenes (total)

<u>Herbicides, Pesticides and PCBs</u>

2,4,5 TP silvex
2,4-D
Alpha-BHC
Beta-BHC
Delta-BHC
Gamma-BHC (Lindane)
Heptachlor
Aldrin
Heptachlor epoxide
Endosulfan I
Dieldrin
4,4'-DDE
Endrin
Endosulfan II
4,4'-DDD
Endosulfan sulfate
4,4'-DDT
Methoxychlor
Endrin ketone
Alpha-Chlordane
Gamma-Chlordane
Toxaphene
Aroclor-1016
Aroclor-1221
Aroclor-1232
Aroclor-1242
Aroclor-1248
Aroclor-1254
Aroclor-1260

<u>Semi-Volatile Organic Compounds</u>

Acenaphthene
2,4-Dinitrophenol
4-Nitrophenol
Dibenzofuran
2,4-Dinitrotoluene
2,6-Dinitrotoluene
Diethylphthalate
4-Chlorophenyl-phenylether
Fluorene
4-Nitroaniline
4,6-Dinitro-2-Methylphenol
N-Nitrosodiphenylamine
4-Bromophenyl-phenylether
Hexachlorobenzene
Pentachlorophenol
Phenanthrene
Anthracene
Di-N-Butylphthalate
Fluoranthene
Pyrene
Butylbenzylphthalate
3,3'-Dichlorobenzidine
Benzo (a) Anthracene
bis (2-Ethylhexyl) Phthalate
Chrysene
Di-N-Octyl Phthalate
Benzo (b) Fluoranthene
Benzo (k) Fluoranthene
Benzo (a) Pyrene
Indeno (1,2,3-cd) Pyrene
Dibenz (a,h) Anthracene
Benzo (g,h,i) Perylene
Phenol
bis (-2-Chloroethyl) Ether
2-Chlorophenol
1,3-Dichlorobenzene
1,4-Dichlorobenzene
Benzyl Alcohol
1,2-Dichlorobenzene
2-Methylphenol
bis (2-chloroisopropyl) Ether

Table 5-1. Proposed Soil Chemical Analysis. (sheet 3 of 3)

Short List of Soil Chemical Analyses

Radionuclides

Gross alpha
Gross beta

Inorganics (Metals)

Arsenic
Chromium
Cadmium
Mercury
Zinc
Potassium

General Chemicals

Ammonia
Flouride
Choride
Nitrate
Sulfate
Sulfamate
Oxalate

Organics

Herbicides
Pesticides
PCBs
Total Organic Carbon
Total Organic Halogens

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Table 5-2. Short and Extensive Lists of Analytical Parameters for Ground and Surface Water. (sheet 1 of 2)

Field Parameters	Short List			
	General Chemical	General Chemical (cont.)	Metals	
pH	Ammonia-N	Total organic carbon	Arsenic	Lead
Conductivity	Biological oxygen demand	Total organic halogen	Cadmium	Mercury
Temperature	Chemical oxygen demand	Conductivity (lab)	Chromium, hexavalent	Sodium
	Chloride		Chromium, total	Zinc
	Nitrate	Radionuclides		
	pH (lab)			
	Sulfate	Gross alpha; Tritium		
	Total dissolved solids	Gross beta		

Extensive List

General Chemical	Radionuclides		Herbicides, Pesticides & PCB's
Alkalinity/acidity	Americium-241	Plutonium	2,4,5 TP Silvex
Ammonia-N	Carbon-14	Strontium-90	2,4,D
Bicarbonate	Gamma scan[1]	Technetium-99	Alpha-BHC
Biological oxygen demand	Gross alpha	Tritium	Beta-BHC
Carbonate	Gross beta	Uranium	Delta-BHC
Chemical oxygen demand	Iodine-129		Gamma-BHC (Lindane)
Chloride			Heptachlor
Dissolved oxygen			Aldrin
Fluoride	Metals and Cyanide		Heptachlor Epoxide
Hardness			Endosulfan I
Nitrate	Aluminum	Iron	Dieldrin
pH (lab)	Antimony	Lead	4,4'-DDE
Phosphate	Arsenic	Magnesium	Endrin
Sulfate	Barium	Manganese	Endosulfan II
Total dissolved solids	Beryllium	Mercury	4,4'-DDD
TOC	Cadmium	Nickel	Endosulfan sulfate
Total organic halogen	Chromium, hexavalent	Potassium	4,4'-DDT
Total suspended solids	Chromium, total	Selenium	Methoxychlor
Conductivity (lab)	Cobalt	Silver	Endrin Ketone
	Copper	Sodium	Alpha-Chlordane
	Cyanide	Thallium	Gamma-Chlordane
		Vanadium	Toxaphene
		Zinc	Aroclor-1016, -1221, -1232 -1242, -1248, -1254, -1260

Table 5-2. Short and Extensive List of Analytical Parameters for Ground and Surface Water. (sheet 2 of 2)

Volatile Organic Compounds

Chloromethane
Bromomethane
Vinyl chloride
Chloroethane
Methylene chloride
Acetone
Carbon disulfide
1,1-Dichloroethene
1,1-Dichloroethane
1,2-Dichloroethene (total)
Chloroform
1,2-Dichloroethane
2-Butanone
1,1,1-Trichloromethane
Carbon tetrachloride
Vinyl acetate
Bromodichloromethane
1,2-Dichloropropane-cis-1,3-Dichloropropane
Trichloroethene
Dibromochloromethane
1,1,2-Trichloromethane
Benzene
trans-1,3-Dichloropropane
Bromoform
4-Methyl-2-pentanone
2-Hexanone
Tetrachloroethane
Toluene
1,1,2,2-Tetrachloroethane
Chlorobenzene
Ethyl benzene
Styrene
Xylenes (total)

Semi-Volatile Organic Compounds[2]

Phenol
bis (-2-Chloroethyl) Ether
2-Chlorophenol
1,3-Dichlorobenzene
1,4-Dichlorobenzene
Benxyl Alcohol
1,2-Dichlorobenzene
2-Methylphenol
N-Nitroso-Di-Propylamine
Hexachloroethane
Nitrobenzene
Isophorone
2-Nitrophenol
2,4-Dimethylphenol
Benzoic acid
bis (-2-Chloroethoxy) Methane
2,4-Dichlorphenol
1,2,4-Trichlorobenzene
Naphthalene
4-Chloroaniline
Hexachlorobutadiene
4-Chloro-3-Methylphenol
2-Methylnaphthalene
Hexachlorocyclopentadienc
2,4,6-Trichlorophenol
2,4,5-Trichlorophenol
2-Chloronaphthalene
2-Nitroaniline
Dimethyl phthalate
Acenaphthylene
3-Nitroaniline
Acenaphthene
2,4-Dinitrophenol
4-Dinitrotoluene
Dibenzofuran
2,4-Dinitrotoluene
2,6-Dinitrotoluene
Diethylphthalate
4-Chlorophenyl-phenylether
Fluorene
4-Nitroaniline
4,6-Dinitro-2-Methylphenol
N-Nitro-sodiphenylamine
4-Bromophanyl-phenylether
Hexachlorobenzene
Pentachlorophenol
Phenanthrene
Anthracene
Di-N-Butylphthalate
Fluoranthene
Pyrane
Butylbenzyl-phthalate
3,3'-Dichlorobenzidine
Benzo (a) Anthracene
bis (2-Ethylhexyl) Phthalate
Chrysene
Di-N-Octyl Phthalate
Benzo (b) Fluoranthene
Benzo (k) Fluoranthene
Benzo (a) Pyrene
Indeno (1,2,3-cd) Pyrene
Dibenz (a,h) Anthracene
Benzo (g,h,i) Perylene

Notes: 1 Gamma scan includes ^{60}Co, ^{63}Ni, ^{134}Cs, ^{152}Eu, ^{154}Eu, ^{106}Ru.
2 Semi-volatiles and Volatile Organic Compounds and listed in approximate order of elution.

Table 5-3. Proposed Well Usage 100-KR-4 Operable Unit. (sheet 1 of 3)

Operable Unit or Area	Well Number	Existing or Proposed	Soil Sampling		Water Level Measurements		Aquifer Testing "Slug Test"	Water Quality Sampling and Analyses				Other	Comments
								Initial		Quarterly	Monthly		
			Physical	Chemical	Recorder	Monthly for One Year		Extensive	Short	Short	Short		
A1 Wells (intersect water table) Ringold unit 1													
KR-1	K11	Ex	N/A	N/A	---	X	X	---	X	---		PNL	Well may be open to both A1 and A2
	K13	Ex	N/A	N/A	---	X	X	---	X	---		---	Condition unknown
	K15	Ex	N/A	N/A	---	X	X	---	X	---		---	Condition unknown
	K19	Ex	N/A	N/A	X	X	X	---	X	---	X	PNL	Cluster with K19A2 and B
	K20	Ex	N/A	N/A	X	X	X	---	X	X		PNL	Cluster with K20A2
	K21	Ex	N/A	N/A	---	X	X	---	X	---		---	Condition unknown
	K22	Ex	N/A	N/A	---	X	X	---	X	X		PNL	---
	K23	Ex	N/A	N/A	---	X	X	---	X	---		---	---
	K24	Ex	N/A	N/A		X	X	X	---	X		---	Condition unknown
	K25	Ex	N/A	N/A	---	X	X	X	---	X		---	Condition unknown
	K40A1	Pr	---	---	X	X	X	X	---	X		---	Cluster with K40A2 and B
	K42A1	Pr	X	X	X	X	X	X	---		X	---	Near 100-N Area
KR-2	K27	Ex	N/A	N/A		X	X	X	---		X	RCRA	Pair with K27A2
	K28	Ex	N/A	N/A	---	X	X	---	X	---		RCRA	---
	K29	Ex	N/A	N/A	---	X	X	---	X	---		RCRA	---
	K30	Ex	N/A	N/A	---	X	X	---	X	X		RCRA	---
	K38A1	Pr	X	X	X	X	X	X	---	X		---	---
	K39A1	Pr	---	---		X	X	X	---	X		---	Pair with K39A2
	K41A1	Pr	X	X	---	X	X	X	---	---			

Table 5-3. Proposed Well Usage 100-KR-4 Operable Unit. (sheet 2 of 3)

Operable Unit or Area	Well Number	Existing or Proposed	Soil Sampling		Water Level Measurements		Aquifer Testing "Slug Test"	Water Quality Sampling and Analyses				Other	Comments
			Physical	Chemical	Recorder	Monthly for One Year		Initial		Quarterly	Monthly		
								Extensive	Short	Short	Short		
A1 Wells (cont.)													
KR-3	K36A1	Pr	X	X	X	X	X	X	---	X		---	---
	K35A1	Pr	X	X	---	X	X	X	---	X		---	---
	K37A1	Pr	X	X	---	X	X	X	---	X		---	---
600	K32A1	Pr	X	X	X	X	X	---	X	X		---	---
	K33A1	Pr	X	X		X		X				---	X
	K34A1	Pr	---	---	X	X	X	---	X	---	X	---	Cluster with K34A2 and B
	6-66-64	Ex	N/A	N/A	---	X	X	---	X	---		PNL	May be an A2 well
	6-70-68	Ex	N/A	N/A	---	X	X	---	X	X		PNL	---
	6-72-73	Ex	N/A	N/A	---	X	X	---	X	X		PNL	May need to be sealed
	6-73-61	Ex	N/A	N/A	---	X	X	---	X	---		PNL	May be an A2 well
	6-78-62	Ex	N/A	N/A	---	X	X	---	X	X		PNL	May need to be sealed
A2 Wells (base of Ringold unit 1)													
KR-1	K19A2	Pr	---	---	X	X	X	X	---		X	---	Cluster with K19A1 and B
	K20A2	Pr	X	X	X	X	X	X	---	X		---	Pair with K20A1
	K40A2	Pr	---	---	X	X	X	X	---		X	---	Cluster with K40A1 and B
KR-2	K10	Ex	N/A	---	---	X	X	---	X	---		---	---
	K27A2	Pr	X	X	---	X	X	X	---		X	---	Pair with K27A1
	K39A2	Pr	X	X	---	X	X	X	---	X		---	Pair with K39A1
600	K34A2	Pr	---	---	X	X	X	X	---		X	---	Cluster with K34A1 and B

Table 5-3. Proposed Well Usage 100-KR-4 Operable Unit. (sheet 3 of 3)

Operable Unit or Area	Well Number	Existing or Proposed	Soil Sampling		Water Level Measurements		Aquifer Testing "Slug Test"	Water Quality Sampling and Analyses				Other	Comments
			Physical	Chemical	Recorder	Monthly for One Year		Initial		Quarterly	Monthly		
								Extensive	Short	Short	Short		
B Wells (Ringold unit 2B)													
KR-1	K19B	Pr	X	X	X	X	X	X	---		X	---	Cluster with K19A1 and A2
	K40B	Pr	X	X	X	X	X	X	---		X	---	Cluster with K40A1 and A2
600	K34B	Pr	X	X	X	X	X	X	---		X	---	Cluster with K34A1 and A2
Basalt Well													
600	6-81-62	Ex(?)	On-file	---	X	X	---	X	---	X		PNL	---

Notes:

See Figure FSP-2 for schematic of well completion intervals and Figure FSP-2 and Plate 2 for proposed well locations.

Well numbers have been abbreviated, e.g., 199-K-1 has been shortened to K-1.

Wells K1, K2, K3, K4, K5, K6, K7, K8, K9, 6-74-74 and 6-80-62 have reportedly been abandoned, that is the casing has been pulled or the well was filled in. However, some water quality data was reported for Well K7 in May 24, 1983. Well K-12 is noted as "covered over."

Wells K11, K15, and 6-72-73 may need to be sealed because of multiple screen depths.

Insufficient information is currently available to determined if Wells K12, K13, K14, K17, K18, K26, and K31 are usable.

PNL = Pacific Northwest Laboratories.

RCRA = Resource Conservation and Recovery Act of 1976.

NA = Not applicable.

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Table 5-4. Soil and Rock Physical and Physicochemical Laboratory Analyses to be Performed as Part of the Characterization of the 100-KR-1 Operable Unit. (sheet 1 of 2)

Laboratory analysis	Parameter measured	Sample requirements/ limitations	Potential uses	Sample frequency	Method of collection[a]	References
Sieving	Particle size distribution of sand to gravel-sized particles	Individual particles must be disaggregated and unbroken to yield accurate results	Proxy for hydraulic parameters, ground water modeling, estimate sorption properties	Every 5 ft or change in lithology	H, D, S	ASTM 1972, Gee and Bauder 1986
Hydrometer	Particle size distribution of mud-sized particles (siltand clay)	<2-mm sediment size fraction	Characterize aquitards, ground water modeling, estimate sorption properties	All fine-grained intervals	H, D, S	ASTM 1972, Gee and Bauder 1986
Permeameter	Saturated hydraulic conductivity	Undisturbed/intact sedimentary core	Small-scale estimate of ground water travel time, check for aquifer tests, ground water modeling	Selected intervals	S	ASTM 1968, Klute and Dirksen 1986
Moisture content	Percentage water	Vadose zone samples	Identify perched water zones, vadose zone modeling	Every 5 ft or change in lithology above the water table	D, S	ASTM 1980
CO_2 gasometer[b]	Percentage $CaCO_3$ content	<2-mm sediment-size fraction	Identify aquitard, straigraphic marker horizons, chemical interactions	Every 5 ft or change in lithology	H, D, S	Nelson 1986
Saturated paste[b] pH	pH	Bulk samples (-20 g)	Evaluate chemical interations with contaminants	Evey 5 ft or change in lithology	H, D, S	McLean 1986
Organic carbon[b] content	Organic carbon	<2-mm sediment-size fraction	Evaluate organic sorption capacity	Every 5 ft or change in lithology	H, D, S	Nelson and Sommers 1986
Ammonium acetate[b] extraction	Cation exchange capacity	<2-mm sediment-size fraction	Sorptive properties	Every 5 ft or change in lithology	H, D,	Rhoades 1986

Table 5-4. Soil and Rock Physical and Physicochemical Laboratory Analyses to be Performed as Part of the Characterization of the 100-KR-1 Operable Unit. (sheet 2 of 2)

Laboratory analysis	Parameter measured	Sample requirements/ limitations	Potential uses	Sample frequency	Method of collection[a]	References
Petrography[b]	Mineral content/ concentration	Sand-sized fraction	Determine sorpitve potential of primary mineral species, differentiate among hydrostratigrahic units	Every 5 ft or change in lithology	H, D, S	Kerr 1959
Soil[b] retention curves	Matric potential and moisture content	Vadose zone samples	Determine hydraulic conductivity	Every 5 ft or change in lithology	H, D, S	TBD
X-ray diffraction[b]	Clay mineral identification	Fine-grained sediments (silt and clay)	Sorptive characteristics, hydrostratigraphic unit identification	Selected fine-grained intervals	D, S	Drever 1973, Rich and Barnhisel 1977, MacEwan and Wilson 1980
Adsorption tests[b]	Chemcial change from influent to effluent	<2-mm-sized fraction from representative sediment sample	Determine distribution coefficient for risk assessment and remedial alternatives	Selected representative sediment samples from below water table (analyze in conjunction with contaminated vadose zone samples)	D, S	Relyea et al. 1980, ASTM 1983
Leaching[b]/ desorption tests	Release from contaminants from sediments	<2-mm-size fraction from representative sample or material from adsorption test	Determine distribution coefficient for risk assessment and remedial alternatives	Selected representative sediment samples from below water table (analyze in conjunction with contaminated vadose zone samples)	D, S	Gallagher 1979, ASTM 1988a
Bulk mass density[b]	Bulk porosity	Undisturbed/intact sedimentary core	Determine hydraulic parameters, ground water modeling	Selected intervals	S	ASTM 1986

[a] H = hard tool (may not be representative of the formation; D = drive-barrel drill method; S = split spoon drill method; C = diamond core.
[b] K-34B only.

6.0 SCHEDULE

The schedule for the conduct of the 100-KR-4 operable unit RI/FS is presented in Figure 6-1 and a schedule integrated with the 100-KR-1 operable unit schedule is presented in Figure 6-2. Assumptions used to generate the schedules include the following:

- Full funding for the 100-KR-1 and 100-KR-4 operable units is available as specified in the FY 1992-1996 Environmental Restoration and Waste Management Five-Year Plan Activity Data Sheets* (Five-Year Plan). If full funding is not available the schedule will be adjusted to reflect actual funding levels.

- Funding for the 100-KR-2 and 100-KR-3 operable units is not considered in this schedule.

- The 100-KR-4 and 100-KR-1 operable unit work plans will be approved by December 31, 1991.

- The NEPA documentation will be in place and approved by October 1, 1991, and will not impede the conduct of site characterization activities.

- Activities for the 100-KR-2 and 100-KR-3 operable units considered in this schedule only to the extent needed to support the source operable unit screening activity in 100-KR-4, Task 2d, Operable Unit Characterization.

- Funding for the two units (100-KR-4 and 100-KR-1) is combined into a common pool and allocated to support the integrated schedule, without regard to the yearly operable unit funding breakdown presented in the Five-Year Plan.

- The schedule addresses only the work activities detailed in the work plan. Provisions for imminent and substantial endangerment actions and interim response actions are not included.

- Durations for characterization/treatability, corrective measures development and corrective measures analysis are generic and not based on any specific knowledge of the operable units. Additional site characterization (as part of the FS Phase II Treatability Investigation activity Task 2 Through 8) has been scheduled for a 1-yr duration

- Concurrent DOE/Ecology/EPA review of primary documents will take 4 mo. This includes 45 d for review, 45 d for comment incorporation and revision, and 30 d for acceptance and approval. No provision is included for delays to the schedule if dispute resolution is needed.

- Activity phases may be initiated upon submittal of the primary reports for review to the regulatory agencies.

- Source investigation tasks under the operable unit activity can be conducted before the approval of the work plans.

* The FY 1992-1996 Environmental Restoration and Waste Management Activity Data Sheets are available at the DOE-RL Public Reading Room in Richland, Washington.

Figure 6-1 will be provided pending final schedule resolutions of investigations at the 100-H and 100-DR areas.

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7.0 PROJECT MANAGEMENT

Execution of the project management plan will require that all activities be performed cooperatively between subcontractor, Westinghouse Hanford, the DOE, EPA, and Ecology.

The progress in completing the 100-KR-4 operable unit work plan will be documented through monthly project activity reports, unit manager meetings, and technical interchanges. Project management tasks will include the following:

- Writing, reviewing, and commenting on documents
- Maintaining administrative record files
- Distributing documents and correspondence
- Maintaining formal change control system for modifying the work schedule in the 100-KR-4 operable unit work plan
- Determining financial and project tracking requirements
- Coordinating project activities among EPA, Ecology, the DOE, Westinghouse Hanford and subcontractors
- Determining scoping study efforts if required
- Determining if interim remedial action is required
- Completing progress reports
- Attending technical interchange meetings.

These and other details of project management are discussed in Attachment 3, Project Management Plan.

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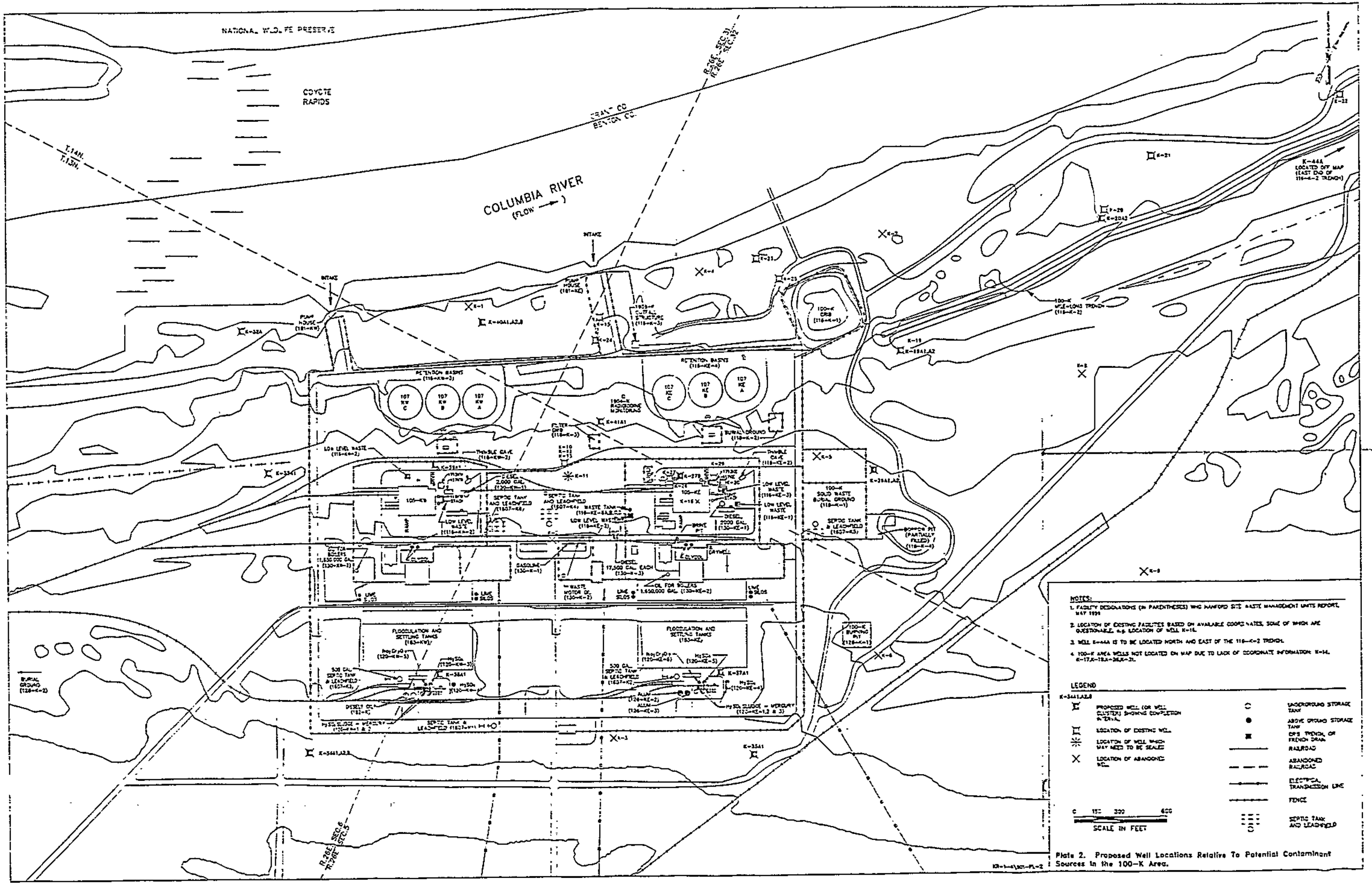

Plate 2. Proposed Well Locations Relative To Potential Contaminant Sources in the 100-K Area.

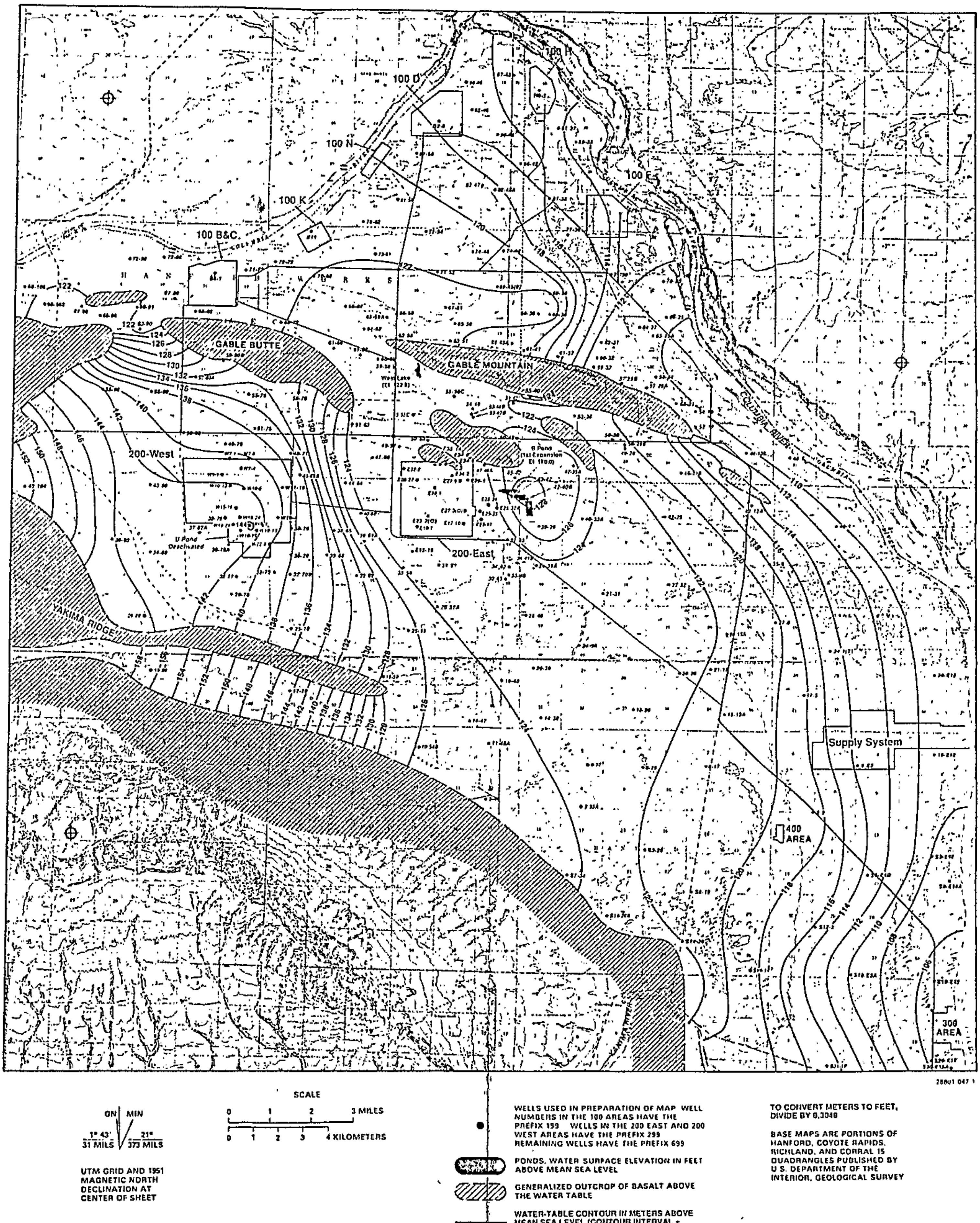

PLATE 1. HANFORD SITE WATER-TABLE MAP, JUNE 1989

Attachment 1

SAMPLING AND ANALYSIS PLAN

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CONTENTS

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1.0 INTRODUCTION

1.1 BACKGROUND

The U.S. Environmental Protection Agency (EPA) has included the 100 Area at the Hanford Site on the National Priorities List (NPL) under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*. The 100-K Area has been divided into three source or surface operable units (100-KR-1, 100-KR-2, and 100-KR-3), and one ground water operable unit (100-KR-4), for the purpose of focusing and managing the necessary environmental investigations, studies, and actions. Ground water, surface water, and riparian and aquatic biota are being addressed in the 100-KR-4 operable unit. Details of this operable unit are presented in the 100-KR-4 operable unit work plan.

1.2 PURPOSE AND OBJECTIVES

The purpose of the sampling and analysis plan (SAP) is to describe field procedures and sample locations that will be used to meet the specific objectives for each field task described in Chapter 5.0 of the 100-KR-4 operable unit work plan. However, this document will not include the detailed descriptions of all of the field procedures that are typically found in an SAP. Instead, wherever possible, specific procedures will be referred to the latest version of the Westinghouse Hanford environmental investigations and instructions (EII); WHC-CM-7-7 (WHC 1989). This is done to provide a level of consistency of data collection methods (and ultimately data quality and usability) employed at the 100-KR-4 operable unit and with those used at other areas within the Hanford Site. A copy of the EII must be used in conjunction with this SAP. It is important that the procedures in these documents be referenced and followed.

1.3 CONTENTS

This SAP consists of two parts:

- Part 1--Field Sampling Plan (FSP)
- Part 2--Quality Assurance Project Plan (QAPP).

The FSP and QAPP each conform with EPA guidance with respect to content and format (EPA 1988). All procedures (including participant contractor or subcontractor procedures) required for this project shall be approved as being in compliance with Westinghouse Hanford criteria.

2.0 REFERENCES

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended, Public Law 96-510, 94 Stat. 2767, 42 USC 9601 et seq.

EPA, 1988, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (Interim Final)*, EPA/540/G-89/004, OSWER Directive 9335.3-01, Office of Solid Waste and Emergency Response, Washington, D.C.

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Part 1

FIELD SAMPLING PLAN

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CONTENTS

CONTENTS (cont)

FIGURES

TABLES

1.0 INTRODUCTION

This field sampling plan (FSP) is Part 1 of Attachment 1, the sampling and analysis plan (SAP), of the RI/FS work plan for the 100-KR-4 operable unit. This plan provides direction for obtaining field samples for implementation of the RI for the 100-KR-4 operable unit and is designed to be used in conjunction with the 100-KR-1 operable unit work plan, other attachments to that plan, and referenced procedures. This plan references many of the sampling and related procedures to the Westinghouse Hanford, *Environmental Investigations and Site Characterization Manual*, WHC-CM-7-7, (WHC 1989). Sampling contractors shall be familiar with, and use, WHC-CM-7-7 manual and the SAP.

The 100-KR-4 operable unit work plan contains important summaries on the background and setting of 100-KR-4 operable unit in the first three chapters and a description of the objectives of the FSP in Section 5.0. Field personnel should be aware of the project schedule contained in Chapter 6.0 of the 100-KR-4 operable unit work plan (or the most recent update of that schedule).

The quality assurance project plan (QAPP, Attachment 1, Part 2) must be used with this FSP. The QAPP references the sampling procedures, analytical procedures, and quality assurance requirements that must be used to obtain good representative field samples and measurements. The health and safety plan (HSP, Attachment 2), which specifies procedures for occupational health and safety protection, will be used by project field personnel. The data management plan (DMP, Attachment 4) includes the requirements for field notebooks and required data procedures.

The FSP is organized by select RI Phase I tasks, the field and laboratory subtasks, and activities. If additional field sampling or measurement requirements are necessary in the 100-KR-4 operable unit characterization or other phases of the project, this plan will incorporate such requirements by amendment according to Section 3.0 of the project management plan (PMP, Attachment 3). Standard field procedures are presented in Chapter 10.0.

The RI Phase I program includes the following tasks:

- Task 1--Project Management (not included in the FSP as it is not field oriented)

- Task 2--Source Investigation

  Subtask 2b--Field Activities
  - Site walkover survey

- Task 3--Geologic Investigations

  Subtask 2b--Field activities
  - Geologic mapping

  Subtask 2c--Laboratory Analysis

- Task 4--Surface Water and Sediment Investigation

  Subtask 4a--Field activities
  - Shoreline mapping
  - Shoreline radiation mapping
  - River bank springs
  - Seepage measurements
  - River stage measurement

  Subtask 4c--Laboratory analysis

  - Soil chemical properties
  - Water chemical properties

- Task 5--Vadose Investigations

  Subtask 5b--Field activities
  - Sampling

  Subtask 5c--Laboratory analysis
  - Soil chemical properties

- Task 6--Ground Water Investigations

  Subtask 5b--Field activities
  - Evaluation of existing wells
  - Well installation
  - Water level measurement
  - Aquifer testing
  - Ground water sampling

  Subtask 5c--Laboratory analysis
  - Soil physical properties
  - Ground water chemistry

- Task 7--Air Investigations

- Task 8--Ecological Investigation

  Subtask 8b--Field activities
  Subtask 8c--Laboratory analysis

- Task 9--Other Investigations

  Subtask 9a--Cultural investigation
  Subtask 9b--Topographic investigation.

2.0 TASK 2--SOURCE INVESTIGATIONS

The purpose of the source investigation for the 100-KR-4 operable unit is to identify the locations and type of sources that exist in the 100-KR-1, 100-KR-2, 100-KR-3 operable units that may contribute to ground water contamination in the 100-KR-4 operable unit. Another concern is that cross contamination is possible when drilling through highly contaminated materials in one of the source operable units. One field activity and a site walkover survey will be conducted in Task 2--Source Investigations. This latter activity is conducted in conjunction with the evaluation of existing wells during the ground water investigation.

2.1 SITE WALKOVER SURVEY

This walkover will be conducted in conjunction with the 100-KR-1 operable unit investigation. The survey team will be equipped with radiation survey instruments for health and safety monitoring and field volatile organic monitoring instruments. The objective of the survey will be to identify subsurface and surface features of concern to the RI/FS that are not properly located on available records or that have not been identified in the records search. These will be located on the site map developed in subtask 9b--topographic investigations.

Observations shall be documented in logbooks in accordance with EII 1.5. Special attention will be given to areas where there is evidence of past disturbance, mounded or subsidence areas that may indicate buried facilities, old foundations, monuments indicating the location of items, and indications of former seepage pits or drains, etc. Areas of potential concern will be staked (flagged) and marked on the site topographic base map, developed under Subtask 9b.

The focus will be on visual observation and field screening of radiation exposure rates and airborne and soil gas concentrations of volatile organic compounds (VOC). Soil gas measurements for VOCs will be made by digging a small hole with a shovel and taking a brief measurement with a photo-ionization or flame ionization detector. The information from this survey will be used to minimize the potential for unexpected radiation or VOC exposure during subsequent tasks and to modify subsequent tasks to account for information that was not available from the historic files. Surface geologic mapping will be performed in conjunction with the area walkover.

3.0 TASK--GEOLOGIC INVESTIGATIONS

A geologic investigation for the 100-KR-4 operable unit will be performed to obtain the geometry of the vadose and ground water system and the nature of unsaturated and saturated sediments that make up this system. One field activity (geologic mapping) is conducted under Subtask 3c--Field Activities. The Phase I geologic investigation does not include sampling at any sites solely for collection of geologic information. Therefore, geologic information (e.g., physical properties, borehole logging) will be collected and analyzed during the other 100-KR-4 operable unit investigations, specifically in Tasks 5 and 6.

3.1 GEOLOGIC MAPPING

Surface geologic mapping will be performed at a scale of approximately 1:500 using the topographic map prepared in Subtask 9b as the base map. Mapping will identify the types and areal extent of surficial deposits within and adjacent to the 100-KR-4 operable unit, including dune and sheet sand, alluvium, colluvium, and loess, as well as fly ash and backfill materials. The mapping will include the large areas of artificial fill and other unnatural features. Aerial photographs will be reviewed and information from the site walkover observations will be included. Relevant information from the existing boring logs will be incorporated into this mapping task. A surface geologic map will be prepared.

4.0 TASK 4--SURFACE WATER AND SEDIMENT INVESTIGATIONS

The objective of Task 4 is to evaluate the impact of 100-K Area facilities on the shoreline of the Columbia River in the area, and on river water and sediment quality. The complete investigation will compile and interpret existing data on sediment and water quality in the area; collect new data to fill in gaps; and interpret the results of the field program relative to a risk assessment and selection of appropriate remedial actions. The following paragraphs describe the sampling and analysis activities associated with this task. Six activities are associated with Subtask 4b--Field Activities, and two activities are associated with Subtask 4c--Laboratory Analysis.

4.1 SUBTASK 4b--FIELD ACTIVITIES

The six field activities necessary for the surface water and sediment investigations are the following:

- Shoreline mapping
- Shoreline radiation survey
- River bank springs sampling
- River bank sediment sampling
- Seepage measurement
- River stage measurement.

4.1.1 Shoreline Mapping

A shoreline base map will be developed using the standard USGS topographic quadrangle that covers the 100-K Area. The locations of known springs, radioactive zones, facilities, monitoring wells, and reliable survey reference points will be plotted. Aerial photographs will be examined for other features that may have significance to this investigation. The area of coverage will extend from approximately 0.5 mi (0.8 km) upstream of the 100-K Area to slightly downstream of the 116-K-2 trench. It will include the 100-K Area and extend to the opposite shoreline of the Columbia River.

Field checking of the base map will be accomplished at the same time as the shoreline radiation survey (Section 4.1.2). At this time, the current locations of active springs, and the locations of any other features not already mapped, will be updated on the base map. Features of interest will be staked and located relative to a known reference point, and photographs will be obtained to document the feature. Surficial deposits, including drift materials found along the Columbia River shore, will be described and outlined on the map.

4.1.2 Shoreline Radiation Survey

A radiation survey along the exposed shoreline within the operable unit will be conducted on foot using a low-level gamma radiation detector. Elevated radiation levels, resulting from the shoreline mapping activity, will be staked in the field and plotted on the topographic base map. Results from these surveys will be compared with background external radiation levels as measured along the shoreline upstream of the Hanford Site, with results of similar surveys conducted previously (e.g., Sula 1980), and with applicable external radiation protection dose limits. The work will be conducted by a qualified health physics technician (HPT). This individual will be responsible for verifying proper working condition of the instrument and for recording field measurements in accordance with EII 2.3, Radiation Survey (WHC 1989).

4.1.3 River Bank Springs Sampling

All river bank springs with sufficient flow will be sampled from the stretch above Coyote Rapids to directly downstream of the 116-K-2 trench. Approximate locations for springs identified in previous studies are provided in Figure FSP-1. Sampling locations for background water quality will be determined after reviewing data collected in Subtask 4A. Spring samples will be collected twice per year, coincident with the spring and fall ground water sampling events. Springs that flow intermittently may not be active during the ground water sampling rounds. These springs will be sampled as close to the ground water sampling events as possible. The sample collection protocol will follow that established by McCormick and Carlile (1984).

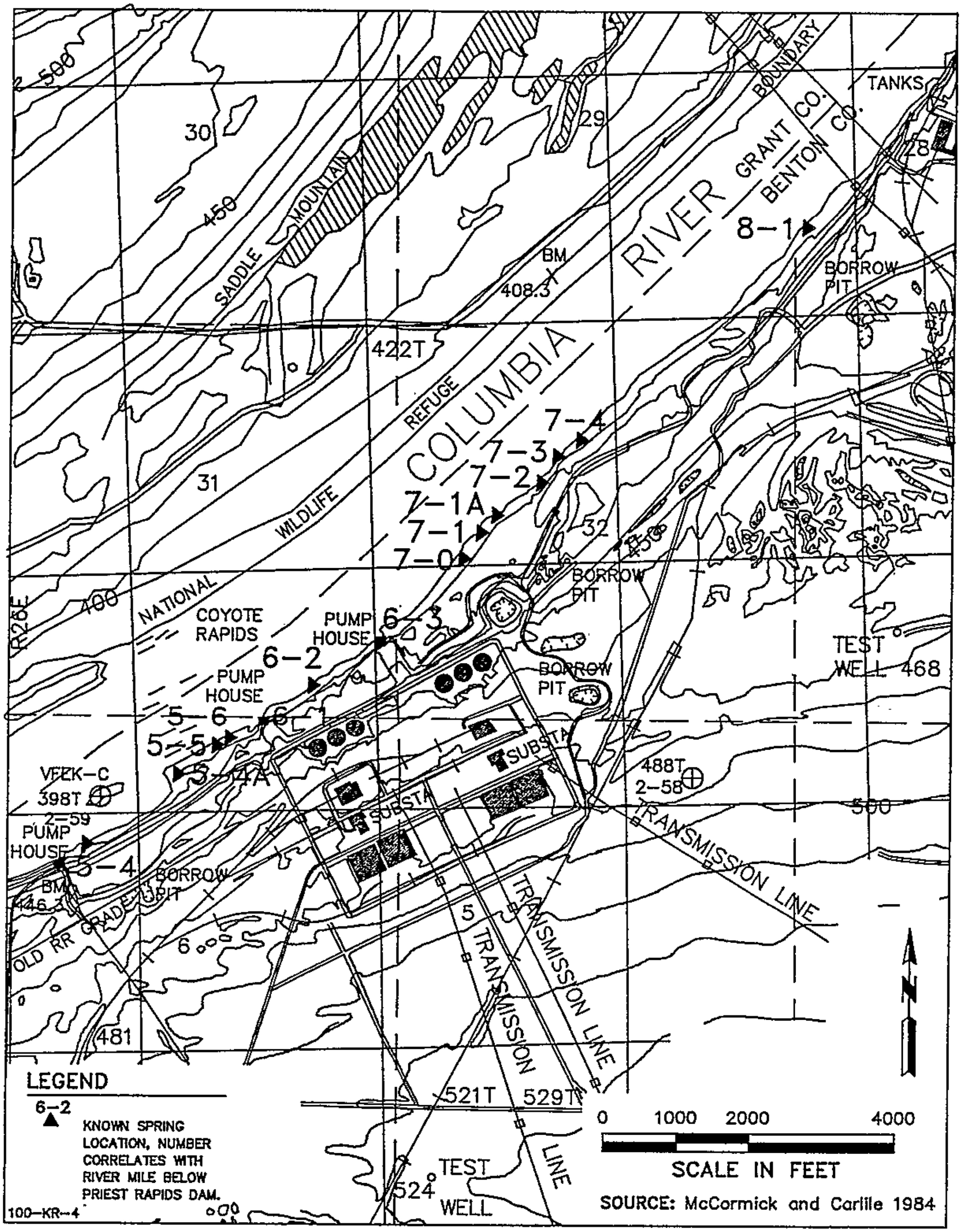


Figure FSP-1. Proposed Spring Sampling Locations. Shoreline Near 100-K Area.

Sampling will be conducted during the low river flow periods to maximize the potential for obtaining representative samples of ground water usage. Cooperation will be sought from the Bonneville Power Administration and the U.S. Army Corps of Engineers in providing low flows and minimizing flow variations from the Priest Rapids Dam during sampling activities. Attempts will be made to collect samples after a lag of several hours so the springs will be most representative of ground water quality. The time of sample collection will be noted for all samples. Temperature, pH, and specific conductance will be measured in the field several times at each spring. Samples for laboratory analysis will be collected after these parameters stabilize.

4.1.4 River Bank and Riverbed Sediment Sampling

Based on the results of the radiation survey, sediment samples will be collected for chemical analyses along the 100-KR-4 operable unit shoreline from those areas considered to have elevated exposure rates (>25 mR/h). This sampling episode will only be conducted once to characterize the residual contamination. Sediment samples will also be obtained from depositional areas in the vicinity of the reactor out fall structure. All sediment samples will be surveyed for radiation, and the sediment characteristics described using a binocular microscope.

4.1.5 Seepage Measurement

Where possible, actual measurement of the spring flow rate will be made. Standard velocity and area measurement techniques will be used to estimate discharges, where actual measurement is not possible. Where seepage occurs over a general area, the flow will be channeled to aid in measuring its volume. If quantitative measurement techniques are impossible, visual estimates will be made. A series of measurements will be made to develop trends in spring flow rates.

4.1.6 River Stage Measurement

A river-gauge station will be located on the Hanford Site side of the Columbia River near the midpoint of the 100-KR-4 operable unit. The gauge will be equipped with a stilling basin, a continuously recording pressure transducer capable of 30-min integration periods and a staff gauge to periodically monitor and calibrate the transducer. The gauge station will be surveyed to the same datum as the observation wells.

4.2 SUBTASK 4c--LABORATORY ANALYSIS

Shoreline samples will be tested for the short list of chemical properties and contaminants of concern (Table FSP-1).

Table FSP-1. Proposed Soil Chemical Analysis. (sheet 1 of 3)

Long List of Soil Chemical Analysis

General Chemical Parameters

Ammonia-N
Carbonate
Chloride
Fluoride
Nitrate
Phosphate
Sulfate
Sulfamate
Oxalate

Radionuclides

Americium-241
Carbon-14
Cobalt-60
Europium-152
Europium-154
Europium-155
Gamma scan
Gross alpha
Gross beta
Iodine-129
Nickel-63
Plutonium
Strontium-90
Technetium-99
Tritium
Uranium

Inorganics (Metals)

Aluminum
Antimony
Arsenic
Barium
Beryllium
Cadmium
Chromium, hexavalent
Chromium (total)

Inorganics (Metals)

Cobalt
Copper
Cyanide
Iron
Lead
Magnesium
Manganese
Mercury
Nickel
Potassium
Selenium
Silver
Sodium
Thallium
Vanadium
Zinc

Volatile Organic Compounds

Chloromethane
Bromomethane
Vinyl chloride
Chloroethane
Methylene chloride
Acetone
Carbon disulfide
1,1-Dichloroethene
1,1-Dichloroethane
1,2-Dichloroethene(total)
Chloroform
1,2-Dichloroethane
2-Butanone
1,1,1-Trichloromethane
Carbon tetrachloride
Vinyl acetate
Bromodichloromethane
1,2-Dichloropropane
cis-1,3-Dichloropropane

Table FSP-1. Proposed Soil Chemical Analysis. (sheet 2 of 3)

<u>Volatile Organic Compounds</u>

Trichloroethene
Dibromochloromethane
1,1,2-Trichloromethane
Benzene
trans-1,3-Dichloropropane
Bromoform
4-Methyl-2-pentanone
2-Hexanone
Tetrachloroethane
Toluene
1,1,2,2-Tetrachloroethane
Chlorobenzene
Ethyl benzene
Styrene
Xylenes (total)

<u>Herbicides, Pesticides and PCBs</u>

2,4,5 TP silvex
2,4-D
Alpha-BHC
Beta-BHC
Delta-BHC
Gamma-BHC (Lindane)
Heptachlor
Aldrin
Heptachlor epoxide
Endosulfan I
Dieldrin
4,4'-DDE
Endrin
Endosulfan II
4,4'-DDD
Endosulfan sulfate
4,4'-DDT
Methoxychlor
Endrin ketone
Alpha-Chlordane
Gamma-Chlordane
Toxaphene
Aroclor-1016
Aroclor-1221
Aroclor-1232
Aroclor-1242
Aroclor-1248
Aroclor-1254
Aroclor-1260

<u>Semi-Volatile Organic Compounds</u>

Acenaphthene
2,4-Dinitrophenol
4-Nitrophenol
Dibenzofuran
2,4-Dinitrotoluene
2,6-Dinitrotoluene
Diethylphthalate
4-Chlorophenyl-phenylether
Fluorene
4-Nitroaniline
4,6-Dinitro-2-Methylphenol
N-Nitrosodiphenylamine
4-Bromophenyl-phenylether
Hexachlorobenzene
Pentachlorophenol
Phenanthrene
Anthracene
Di-N-Butylphthalate
Fluoranthene
Pyrene
Butylbenzylphthalate
3,3'-Dichlorobenzidine
Benzo (a) Anthracene
bis (2-Ethylhexyl) Phthalate
Chrysene
Di-N-Octyl Phthalate
Benzo (b) Fluoranthene
Benzo (k) Fluoranthene
Benzo (a) Pyrene
Indeno (1,2,3-cd) Pyrene
Dibenz (a,h) Anthracene
Benzo (g,h,i) Perylene
Phenol
bis (-2-Chloroethyl) Ether
2-Chlorophenol
1,3-Dichlorobenzene
1,4-Dichlorobenzene
Benzyl Alcohol
1,2-Dichlorobenzene
2-Methylphenol
bis (2-chloroisopropyl) Ether

Table FSP-1. Proposed Soil Chemical Analysis. (sheet 3 of 3)

Short List of Soil Chemical Analyses

Radionuclides	General Chemicals
Gross alpha	Ammonia
Gross beta	Fluoride
	Chloride
Inorganics (Metals)	Nitrate
Arsenic	Sulfate
Chromium	Sulfamate
Cadmium	Oxalate
Mercury	
Zinc	Organics
Potassium	Herbicides
	Pesticides
	PCBs
	Total Organic Carbon
	Total Organic Halogens

Surface water samples will be analyzed for the short list of analytical parameters and contaminants of concern (Table FSP-2). The selection of the analyses of concern for water samples will be based on the results of the initial comprehensive ground water sampling round. Water temperature, pH, and specific conductance will be measured once in the field when samples are collected.

5.0 TASK 5--VADOSE INVESTIGATION

The purpose of the vadose investigation in the Phase I RI for the 100-KR-4 operable unit is to provide information on soil chemistry and physical properties as they relate to potential impacts on ground water (e.g., recharge potential) and to provide supporting information for the 100-KR-1, -2, and -3 source operable unit RIs. Soil samples for analysis will be collected from the vadose zone in conjunction with the monitoring well installation.

The vadose zone investigation includes one field activity (sampling) and one laboratory analysis subtask activity (soil chemical properties). Analysis for soil physical properties of the vadose are discussed in Task 6--Ground Water Investigation.

Table FSP-2. Extensive and Short Lists of Analytical Parameters for Ground and Surface Water 100-KR-4 Operable Unit. (sheet 1 of 2)

Field Parameters	Short List			
	General Chemical	**General Chemical (cont.)**	**Metals**	
pH	Ammonia-N	Total organic carbon	Arsenic	Lead
Conductivity	Biological oxygen demand	Total organic halogen	Cadmium	Mercury
Temperature	Chemical oxygen demand	Conductivity (lab)	Chromium, hexavalent	Sodium
	Chloride		Chromium, total	Zinc
	Nitrate	**Radionuclides**		
	pH (lab)	Gross alpha		
	Sulfate	Gross beta		
	Total dissolved solids	Tritium		

Extensive List				
General Chemical	**Radionuclides**		**Herbicides, Pesticides & PCB's**	
Alkalinity/acidity	Americium-241	Plutonium	2,4,5 TP Silvex	
Ammonia-N	Carbon-14	Strontium-90	2,4,D	
Bicarbonate	Gamma scan[1]	Technetium-99	Alpha-BHC	
Biological oxygen demand	Gross alpha	Tritium	Beta-BHC	
Carbonate	Gross beta	Uranium	Delta-BHC	
Chemical oxygen demand	Iodine-129		Gamma-BHC (Lindane)	
Chloride			Heptachlor	
Dissolved oxygen			Aldrin	
Fluoride	**Metals and Cyanide**		Heptachlor Epoxide	
Hardness			Endosulfan I	
Nitrate	Aluminum	Iron	Dieldrin	
pH (lab)	Antimony	Lead	4,4'-DDE	
Phosphate	Arsenic	Magnesium	Endrin	
Sulfate	Barium	Manganese	Endosulfan II	
Total dissolved solids	Beryllium	Mercury	4,4'-DDD	
TOC	Cadmium	Nickel	Endosulfan sulfate	
Total organic halogen	Chromium, hexavalent	Potassium	4,4'-DDT	
Total suspended solids	Chromium, total	Selenium	Methoxychlor	
Conductivity (lab)	Cobalt	Silver	Endrin Ketone	
	Copper	Sodium	Alpha-Chlordane	
	Cyanide	Thallium	Gamma-Chlordane	
		Vanadium	Toxaphene	
		Zinc	Aroclor-1016, -1221, -1232 -1242, -1248, -1254, -1260	

Table FSP-2. Extensive and Short Lists of Analytical Parameters for Ground and Surface Water 100-KR-4 Operable Unit. (sheet 2 of 2)

Volatile Organic Compounds	Semi-Volatile Organic Compounds[2]	
Chloromethane	Phenol	2,4-Dinitrophenol
Bromomethane	bis (-2-Chloroethyl) Ether	4-Dinitrotoluene
Vinyl chloride	2-Chlorophenol	Dibenzofuran
Chloroethane	1,3-Dichlorobenzene	2,4-Dinitrotoluene
Methylene chloride	1,4-Dichlorobenzene	2,6-Dinitrotoluene
Acetone	Benxyl Alcohol	Diethylphthalate
Carbon disulfide	1,2-Dichlorobenzene	4-Chlorophenyl-phenylether
1,1-Dichloroethene	2-Methylphenol	Fluorene
1,1-Dichloroethane	N-Nitroso-Di-Propylamine	4-Nitroaniline
1,2-Dichloroethene (total)	Hexachloroethane	4,6-Dinitro-2-Methylphenol
Chloroform	Nitrobenzene	N-Nitro-sodiphenylamine
1,2-Dichloroethane	Isophorone	4-Bromophanyl-phenylether
2-Butanone	2-Nitrophenol	Hexachlorobenzene
1,1,1-Trichloromethane	2,4-Dimethylphenol	Pentachlorophenol
Carbon tetrachloride	Benzoic acid	Phenanthrene
Vinyl acetate	bis (-2-Chloroethoxy) Methane	Anthracene
Bromodichloromethane	2,4-Dichlorphenol	Di-N-Butylphthalate
1,2-Dichloropropane-cis-1,3-Dichloropropane	1,2,4-Trichlorobenzene	Fluoranthene
Trichloroethene	Naphthalene	Pyrane
Dibromochloromethane	4-Chloroaniline	Butylbenzyl-phthalate
1,1,2-Trichloromethane	Hexachlorobutadiene	3,3'-Dichlorobenzidine
Benzene	4-Chloro-3-Methylphenol	Benzo (a) Anthracene
trans-1,3-Dichloropropane	2-Methylnaphthalene	bis (2-Ethylhexyl) Phthalate
Bromoform	Hexachlorocyclopentadienc	Chrysene
4-Methyl-2-pentanone	2,4,6-Trichlorophenol	Di-N-Octyl Phthalate
2-Hexanone	2,4,5-Trichlorophenol	Benzo (b) Fluoranthene
Tetrachloroethane	2-Chloronaphthalene	Benzo (k) Fluoranthene
Toluene	2-Nitroaniline	Benzo (a) Pyrene
1,1,2,2-Tetrachloroethane	Dimethyl phthalate	Indeno (1,2,3-cd) Pyrene
Chlorobenzene	Acenaphthylene	Dibenz (a,h) Anthracene
Ethyl benzene	3-Nitroaniline	Benzo (g,h,i) Perylene
Styrene	Acenaphthene	
Xylenes (total)		

Notes: 1 Gamma scan includes ^{60}Co, ^{63}Ni, ^{134}Cs, ^{152}Eu, ^{154}Eu, ^{106}Ru.
2 Semi-volatiles and Volatile Organic Compounds and listed in approximate order of elution.

5.1 SUBTASK 5b--FIELD ACTIVITIES

The vadose zone investigation includes one field activity, which is sampling. As mentioned above, this sampling will be conducted in conjunction with the installation of the ground water monitoring wells; therefore, drilling methods are discussed in Section 6.1.2.2. Collection of samples for physical testing is also discussed in Section 6.1.2.2 because samples for physical testing will be collected both above and below the water table. However, the requirements for chemical sampling are discussed under this task because chemical analyses will be performed mainly on samples collected from above the water table.

5.1.1 Vadose Sampling (for Soil Chemical Parameters)

The following sections discuss sample locations, frequency and depth of sampling, sampling methods, and field screening.

5.1.1.1 Sample Locations. Samples will be collected from the deepest boring at the well cluster locations and at all single well locations as shown in Figure FSP-2 and Plate 2. At the discretion of the site geologist and hydrologist, additional borings may be sampled.

5.1.1.2 Frequency and Depth of Sampling. Samples will be collected at 5-ft (1.6 m) intervals to a depth of 20 ft (6 m), and then at 10-ft (3 m) intervals down to the water table. One sample will also be collected 5-ft (1.6 m) below the water table. Additional soil samples will be collected at the discretion of the site geologist and hydrologist.

5.1.1.3 Sampling Methods. Several methods of sampling may be employed for sampling soils from monitoring well borings. Cable tool drilling methods have been proposed for the monitoring wells from which samples will be taken. However, because of the natural variability of geologic materials, the most appropriate sampling should be done in accordance with EII 5.2. Conditions may be encountered that require less precise methods. For example, the formation may be too coarse to sample with any drive method, so cuttings may be collected from a discrete zone. This may limit the range of appropriate laboratory analyses for such a sample.

5.1.1.4 Field Screening. All the samples will be screened in the field for radionuclides and volatile organic compounds and for visual contamination. In addition, a strategy for using other screening methods (i.e. XRF, specific, conductance, ion selective electrode, head space/GC, solvent extraction/GC, and high resolution spectral gamma) will be developed based on experience gained at other Hanford Site Operable Unit RI's. The screening program will be developed to determine if correlation exists between the results form screening methods an standard laboratory analysis methods. The document, *A Proposed Data Quality Strategy for Hanford Site Characterization*, will be used as guidance. If field screening indicates additional analyses are warranted, appropriate parameters will be selected.

5.2 SUBTASK 5c--LABORATORY ANALYSES

Wells that will have soil samples tested for physical and chemical parameters are shown in Table FSP-3. All samples will be analyzed for the short list of chemical constituents (Table FSP-1), except for the samples from 15 (5 m), 30 (10 m), and 50 ft (16 m), and the sample from below the water table, which will be analyzed for the long list of constituents. Collection of sufficient samples for chemical analyses takes precedence because qualitative information on the physical characteristics can be obtained from the lithologic descriptions (Section 5.2.5).

6.0 TASK 6--GROUND WATER INVESTIGATIONS

The purpose of the ground water investigation is to determine the nature, extent, and movement of ground water contamination in the hydrostratigraphic units underlying the 100-KR-4 operable unit. Several field activities and subactivities will be conducted under subtask 6b and two laboratory analyses activities under subtask 6c.

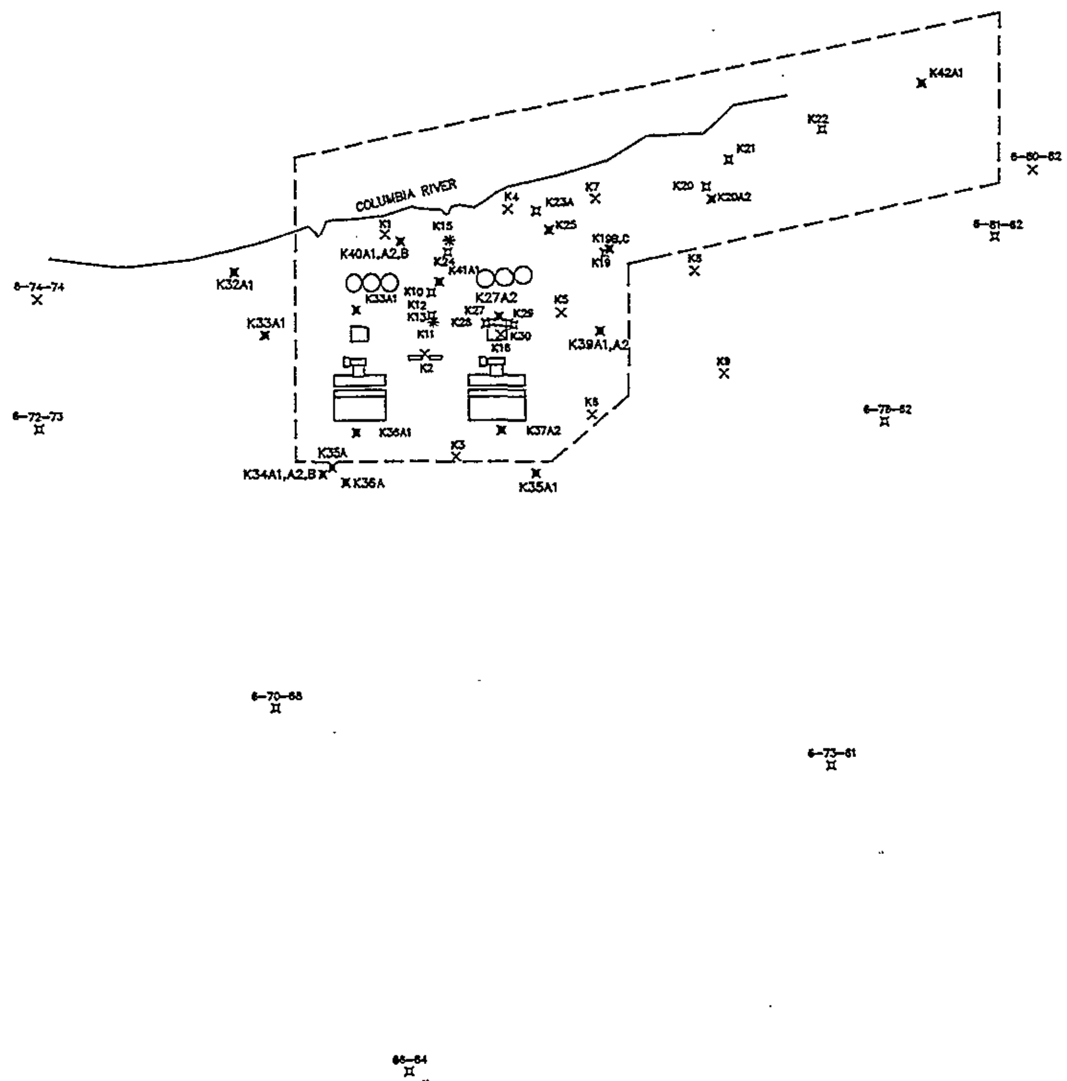
6.1 SUBTASK 6b--FIELD ACTIVITIES

The following field activities under the ground water investigation are discussed:

- Evaluation of existing wells
- Well installation
- Water level measurements
- Aquifer testing
- Ground water sampling.

6.1.1 Evaluation of Existing Wells

Field testing or verification will be required for existing wells at the site, in conjunction with a review of borehole drilling, well construction and installation, and field verification records. Field testing or verification may be required if sufficient information is not available and the location of the well is important to the identified RI objectives. Verification may include field checks of each well to address location, surface protection, capping and identification. In addition, borehole logging (i.e., television camera scans and geophysical logging) may be run to provide borehole information on casing and screen conditions.



NOTE:

LOCATION OF WELLS K-14,K-17, K-18,K-26,K-31,6-71-52,6-77-54, 6-74-74,6-77-71,AND 6-78-62 IN THE 100-K AREA AND VICINITY WERE OMITTED AS A RESULT OF LACK OF COORDINATE INFORMATION.

LEGEND

K32A,B ✕ PROPOSED WELL (OR WELL CLUSTER) LOCATION AND HYDROSTRATIGRAPHIC UNIT (A1, A2, OR B) FOR COMPLETION

K22A ⌘ LOCATION OF EXISTING WELL THAT MAY BE USABLE

K11 ✱ LOCATION OF WELL THAT MAY NEED TO BE SEALED BECAUSE OF MULTIPLE COMPLETION INTERVALS (K-11,K-15, AND 6-72-73)

K9 × LOCATION OF ABANDONED WELL

0 1000 2000 4000

SCALE IN FEET

Figure FSP-2. Existing and Proposed Monitoring Well Locations.

100-KR-4

KR-1-4\901-5-1.DWG

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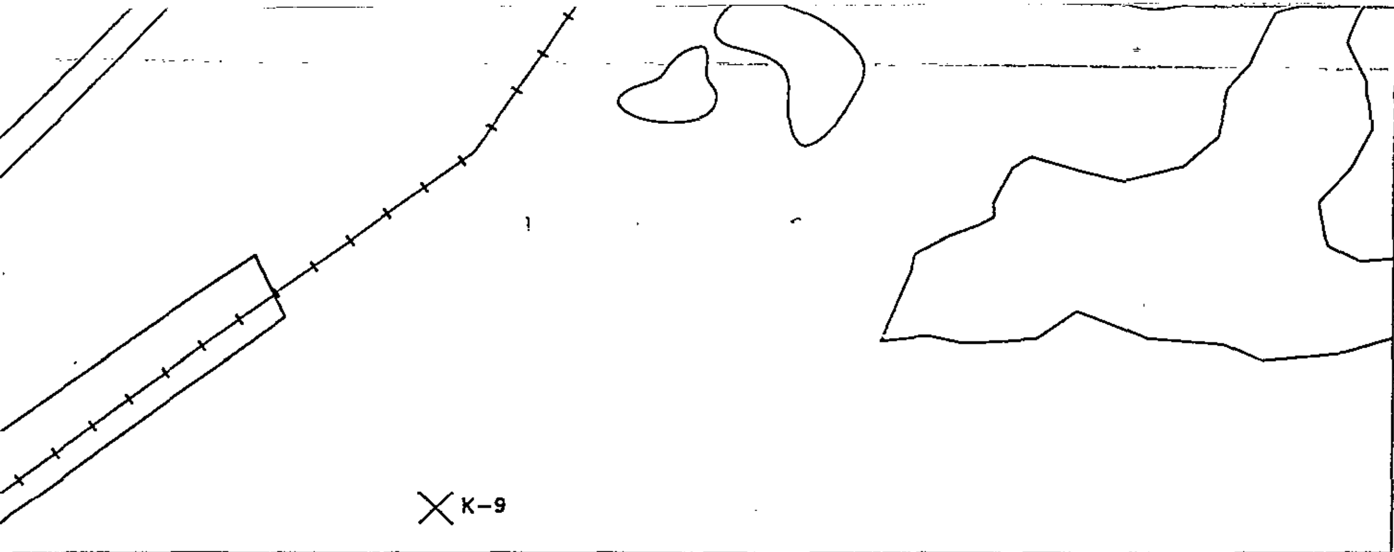

NOTES:

1. FACILITY DESIGNATIONS (IN PARENTHESES) WHC HANFORD SITE WASTE MANAGEMENT UNITS REPORT, MAY 1989.

2. LOCATION OF EXISTING FACILITIES BASED ON AVAILABLE COORDINATES, SOME OF WHICH ARE QUESTIONABLE, e.g. LOCATION OF WELL K-16.

3. WELL K-44A IS TO BE LOCATED NORTH AND EAST OF THE 116-K-2 TRENCH.

4. 100-K AREA WELLS NOT LOCATED ON MAP DUE TO LACK OF COORDINATE INFORMATION: K-14, K-17,K-18,K-26,K-31.

LEGEND

K-34A1,A2,B

PROPOSED WELL (OR WELL CLUSTER) SHOWING COMPLETION INTERVAL

LOCATION OF EXISTING WELL

LOCATION OF WELL WHICH MAY NEED TO BE SEALED

LOCATION OF ABANDONED WELL

UNDERGROUND STORAGE TANK

ABOVE GROUND STORAGE TANK

CRIB, TRENCH, OR FRENCH DRAIN

RAILROAD

ABANDONED RAILROAD

ELECTRICAL TRANSMISSION LINE

FENCE

SEPTIC TANK AND LEACHFIELD

0 150 300 600

SCALE IN FEET

Plate 2. Proposed Well Locations Relative To Potential Contaminant Sources in the 100-K Area.

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Table FSP-3. Proposed Well Usage 100-KR-4 Operable Unit. (sheet 1 of 3)

Operable Unit or Area	Well Number	Existing or Proposed	Soil Sampling		Water Level Measurements		Aquifer Testing "Slug Test"	Water Quality Sampling and Analyses				Other	Comments
								Initial		Quarterly	Monthly		
			Physical	Chemical	Recorder	Monthly for One Year		Extensive	Short	Short	Short		
A1 Wells (intersect water table) Ringold unit 1													
KR-1	K11	Ex	N/A	N/A	---	X	X	---	X	---		PNL	Well may be open to both A1 and A2
	K13	Ex	N/A	N/A	---	X	X	---	X	---		---	Condition unknown
	K15	Ex	N/A	N/A	---	X	X	---	X	---		---	Condition unknown
	K19	Ex	N/A	N/A	X	X	X	---	X	---	X	PNL	Cluster with K19A2 and B
	K20	Ex	N/A	N/A	X	X	X	---	X	X		PNL	Cluster with K20A2
	K21	Ex	N/A	N/A	---	X	X	---	X	---		---	Condition unknown
	K22	Ex	N/A	N/A	---	X	X	---	X	X		PNL	---
	K23	Ex	N/A	N/A	---	X	X	---	X	---		---	---
	K24	Ex	N/A	N/A		X	X	X	---	X		---	Condition unknown
	K25	Ex	N/A	N/A	---	X	X	X	---	X		---	Condition unknown
	K40A1	Pr	---	---	X	X	X	X	---	X		---	Cluster with K40A2 and B
	K42A1	Pr	X	X	X	X	X	X	---		X	---	Near 100-N Area
KR-2	K27	Ex	N/A	N/A		X	X	X	---		X	RCRA	Pair with K27A2
	K28	Ex	N/A	N/A	---	X	X	---	X	---		RCRA	---
	K29	Ex	N/A	N/A	---	X	X	---	X	---		RCRA	---
	K30	Ex	N/A	N/A	---	X	X	---	X	X		RCRA	---
	K38A1	Pr	X	X	X	X	X	X	---	X		---	---
	K39A1	Pr	---	---		X	X	X	---	X		---	Pair with K39A2
	K41A1	Pr	X	X	---	X	X	X	---	---			

Table FSP-3. Proposed Well Usage 100-KR-4 Operable Unit. (sheet 2 of 3)

Operable Unit or Area	Well Number	Existing or Proposed	Soil Sampling		Water Level Measurements		Aquifer Testing "Slug Test"	Water Quality Sampling and Analyses				Other	Comments
			Physical	Chemical	Recorder	Monthly for One Year		Initial		Quarterly	Monthly		
								Extensive	Short	Short	Short		
A1 Wells (cont.)													
KR-3	K36A1	Pr	X	X	X	X	X	X	---	X		---	---
	K35A1	Pr	X	X	---	X	X	X	---	X		---	---
	K37A1	Pr	X	X	---	X	X	X	---	X		---	---
600	K32A1	Pr	X	X	X	X	X	---	X	X		---	---
	K33A1	Pr	X	X		X		X				---	X
	K34A1	Pr	---	---	X	X	X	---	X	---	X	---	Cluster with K34A2 and B
	6-66-64	Ex	N/A	N/A	---	X	X	---	X	---		PNL	May be an A2 well
	6-70-68	Ex	N/A	N/A	---	X	X	---	X	X		PNL	---
	6-72-73	Ex	N/A	N/A	---	X	X	---	X	X		PNL	May need to be sealed
	6-73-61	Ex	N/A	N/A	---	X	X	---	X	---		PNL	May be an A2 well
	6-78-62	Ex	N/A	N/A	---	X	X	---	X	X		PNL	May need to be sealed
A2 Wells (base of Ringold unit 1)													
KR-1	K19A2	Pr	---	---	X	X	X	X	---		X	---	Cluster with K19A1 and B
	K20A2	Pr	X	X	X	X	X	X	---	X		---	Pair with K20A1
	K40A2	Pr	---	---	X	X	X	X	---		X	---	Cluster with K40A1 and B
KR-2	K10	Ex	N/A	---	---	X	X	---	X	---		---	---
	K27A2	Pr	X	X	---	X	X	X	---		X	---	Pair with K27A1
	K39A2	Pr	X	X	---	X	X	X	---	X		---	Pair with K39A1

Table FSP-3. Proposed Well Usage 100-KR-4 Operable Unit. (sheet 3 of 3)

Operable Unit or Area	Well Number	Existing or Proposed	Soil Sampling		Water Level Measurements		Aquifer Testing "Slug Test"	Water Quality Sampling and Analyses				Other	Comments
			Physical	Chemical	Recorder	Monthly for One Year		Initial		Quarterly	Monthly		
								Extensive	Short	Short	Short		
600	K34A2	Pr	---	---	X	X	X	X	---		X	---	Cluster with K34A1 and B
B Wells (Ringold unit 2B)													
KR-1	K19B	Pr	X	X	X	X	X	X	---		X	---	Cluster with K19A1 and A2
	K40B	Pr	X	X	X	X	X	X	---		X	---	Cluster with K40A1 and A2
600	K34B	Pr	X	X	X	X	X	X	---		X	---	Cluster with K34A1 and A2
Basalt Well													
600	6-81-62	Ex(?)	On-file	---	X	X	---	X	---	X		PNL	---

Notes:

See Figure FSP-2 for schematic of well completion intervals and Figure 2 and Plate 2 for proposed well locations.

Well numbers have been abbreviated, e.g., 199-K-1 has been shortened to K-1.

Wells K1, K2, K3, K4, K5, K6, K7, K8, K9, 6-74-74 and 6-80-62 have reportedly been abandoned, that is the casing has been pulled or the well was filled in. However, some water quality data was reported for Well K7 in May 24, 1983. Well K-12 is noted as "covered over."

Wells K11, K15, and 6-72-73 may need to be sealed because of multiple screen depths.

Insufficient information is currently available to determined if Wells K12, K13, K14, K17, K18, K26, and K31 are usable.

PNL = Pacific Northwest Laboratories.

RCRA = Resource Conservation and Recovery Act of 1976.

NA = Not applicable.

Existing wells may require abandonment or remediation. Remediation may consist of sealing upper portions of the casing, addition of a surface pad and protective posts, scrubbing the interior of the casing, replacement (or addition) of a pump, redevelopment of the well, or similar activities.

6.1.2 Well Installation

Several operations are conducted during the well installation activity, specifically; well siting, drilling and sampling, borehole logging, well completion, well development, and well surveying.

6.1.2.1 Well Location. The purpose of this operation is to confirm the subsurface location of underground utilities, cribs, or other buried obstructions at the proposed drilling locations. This operation may not be required at locations that received geophysical testing and radiation monitoring previously during the waste unit source investigation. The source operable units and ground water 100-KR-4 operable unit will share these data to avoid redundancy. These surveys will only be performed once, before drilling, although they can be redone on a local basis if anomalous conditions are detected. Surface assessment for drilling accessibility will also be conducted.

Three geophysical methods will be used for drill location screening: electromagnetic induction (EMI), magnetometer (MAG), and ground penetrating radar (GPR). These methods will be supplemented with a surface radiation survey. A horizontal grid centered over each proposed boring location will be established by a tape and compass traverse. The grid will be 100 by 100 ft (32 by 32 m) or denser, with coordinates established at 25-ft (8-m) centers.

6.1.2.1.1 Electromagnetic Induction/Magnetometer Survey. The EMI equipment measures the electrical conductivity of subsurface materials. Variations in conductivity may be caused by changes in soil moisture content, the presence of ionic species, or the presence of metallic objects. A fluxgate MAG will be used to detect ferro-nickel metallic objects, such as pipelines, buried beneath the surface in the MAG survey. The information generated from these surveys will be incorporated into a location map and will be related to other facility information.

6.1.2.1.2 Ground Penetrating Radar Survey. The GPR survey will be used to screen for non-metallic objects in solid waste landfills, cribs, and other buried features that are not adequately defined by historic records, visual identification, or the EMI/MAG survey. The usefulness of pilot survey results will be checked against the results from the EMI/MAG survey for several locations to determine if it provides supplemental information. If useful supplemental information is provided, the entire survey will be performed.

Continuous strip chart recording equipment will be used to generate profiles of the survey. Digital signal processing equipment may also be used to enhance data interpretation. A geophysicist experienced in the interpretation of GPR data will analyze the profiles to determine locations and depths of anomalies and facility boundaries. This information will be incorporated into a location map and will be related to the other facility information.

6.1.2.1.3 Surface Radiation Survey. The objective of the surface radiation survey is to screen proposed drilling locations for elevated radioactivity in surface soil. The surface radiation survey will be conducted for alpha, beta, and gamma radiation using properly calibrated portable instruments (vehicle-mounted or hand-held as appropriate). The field surveys will be based primarily on gamma surveys; however, alpha and beta measurements will also be made as appropriate.

Because of self-absorption of alpha and beta radiation in the source material and the attenuation in moisture and dirt, alpha and beta radiation are difficult to monitor in the field. Furthermore, the thin windows required on alpha and beta instruments make them very susceptible to damage, and hence the detectors are generally not placed near enough to contamination, when performing large area surveys in the field, to detect low levels of contamination. Because of these difficulties, gamma radiation will be used as the surrogate for all forms of contamination for most of the field survey. Evenly distributed alpha and beta measurements will be taken at 5% of the transect locations and at all locations with elevated levels of gamma radiation.

The gamma survey will use an NaI detector that is cross-calibrated to a tissue-equivalent detector designed to respond in rem or Sieverts/h. The measurements will be made using an instrument that reads in cpm. The traverses between the measurement points will be traveled at a slow rate to allow continuous surveying, and actual measurements along the grid lines (25-ft [8-m] spacing) will be made using a scaler to allow accurate recording of the cpm at that point.

Details on surface radiation survey equipment and procedures will be developed in accordance with EII 1.2. Participant contractor or subcontractor procedures, approved and controlled as specified in Section 4.0 of the QAPP, may be used if no appropriate EII exists. These procedures will include details on equipment specifications, data logging equipment, and calibration and maintenance requirements.

Continuous recording equipment will be used to generate data along the grid lines during the surface radiation survey. An individual experienced in the interpretation of surface radiation data will analyze the data to identify anomalies. The information will be incorporated into a location map and will be related to the other facility information.

6.1.2.2 Drilling and Sampling

6.1.2.2.1 Well Designations. New monitoring wells constructed in the 100-K Area will be given designations consistent with the existing wells on site. These wells have been designated through K31; therefore, the proposed well numbers begin with K32. In well clusters, each well will have the same number but a different suffix to indicate its hydrostratigraphic completion interval (e.g., K34A1, K34A2, or K34B). An A1 suffix indicates the well is completed across the water table in Ringold producing unit A. An A2 suffix indicates the well is completed in the lower portion of producing unit A. A B suffix indicates the well is completed in Ringold confined aquifer B. If wells are later drilled and completed in Ringold confined aquifer D, they will be given a D suffix.

If additional wells are added near an existing well, but at different depths, the existing well number is used and suffixes are added. For example, well K19 is an existing shallow well. Two deeper wells are proposed adjacent to it and will be designated K19A2 and K19B. If an existing well is no longer usable and is replaced, a new designation will be assigned to the replacement well.

The A1 wells will be screened across the water table, which is expected to range from 30 to 80 ft (10 to 27 m) below surface depending upon location within the site and the influence of river stage. The Generic Well Specification (WHC-5-014) will be used for the A wells. The water table is expected to be within the Ringold unit 1. The A2 wells will be screened within the sand and gravel layers at the base of Ringold unit 1, above the clays of Ringold unit 2a. The B wells will be screened below the clays in the Ringold unit 2a within the first sand zone (Figure FSP-3).

6.1.2.2.2 Monitoring Well Locations. Twenty new monitoring wells will be installed at the locations shown in Figure FSP-2 and Plate 2. The locations are approximate and will be finalized after evaluation of information gathered in the source investigation and geophysical and radiation surveys. Eight locations are sited for single well completions (Ringold unit 1). Twelve wells will be completed at six cluster locations. A well cluster consists of two or more well completions at a single location. Some cluster locations (K19, K20, K27) will depend upon the fitness of existing wells. The results of well fitness will identify whether or not existing wells will need to be replaced.

6.1.2.2.3 Drilling Procedures. Drilling methods will follow protocol presented in EII 6. The drilling program is designed to minimize exposure of field personnel and prevent cross contamination between water-bearing zones. Cable-tool drilling is the method of choice for this task because the quantity of drilling residuals is minimal compared with alternative methods (air rotary or mud rotary), and the discharge of formation water and cuttings from the hole can be easily controlled. Other drilling techniques may be considered.

Drive casings will be telescoped as required for casing pull-back and to prevent cross contamination between hydrologic zones. Hanford Site generic specifications will be used for the borehole and casing configurations. As a minimum, distinct hydrostratigraphic units and contaminated zones shall be cased off and sealed before preceding downward with further drilling. If multiple casing strings must be pulled back, then a work-over or pull-back rig, with high lifting capacity may be needed to retrieve casing, place grout, and finish the well installation.

6.1.2.2.4 Soil Physical Property Sampling. Sample locations will be collected from the deepest boring at the well cluster locations and at all single well locations as shown in Figure FSP-2 and Plate 2. At the discretion of the site geologist or hydrologist additional borings may be sampled.

Frequency and Depth of Sampling--Samples will be collected above and below the water table according to the sampling scheme in Table FSP-4.

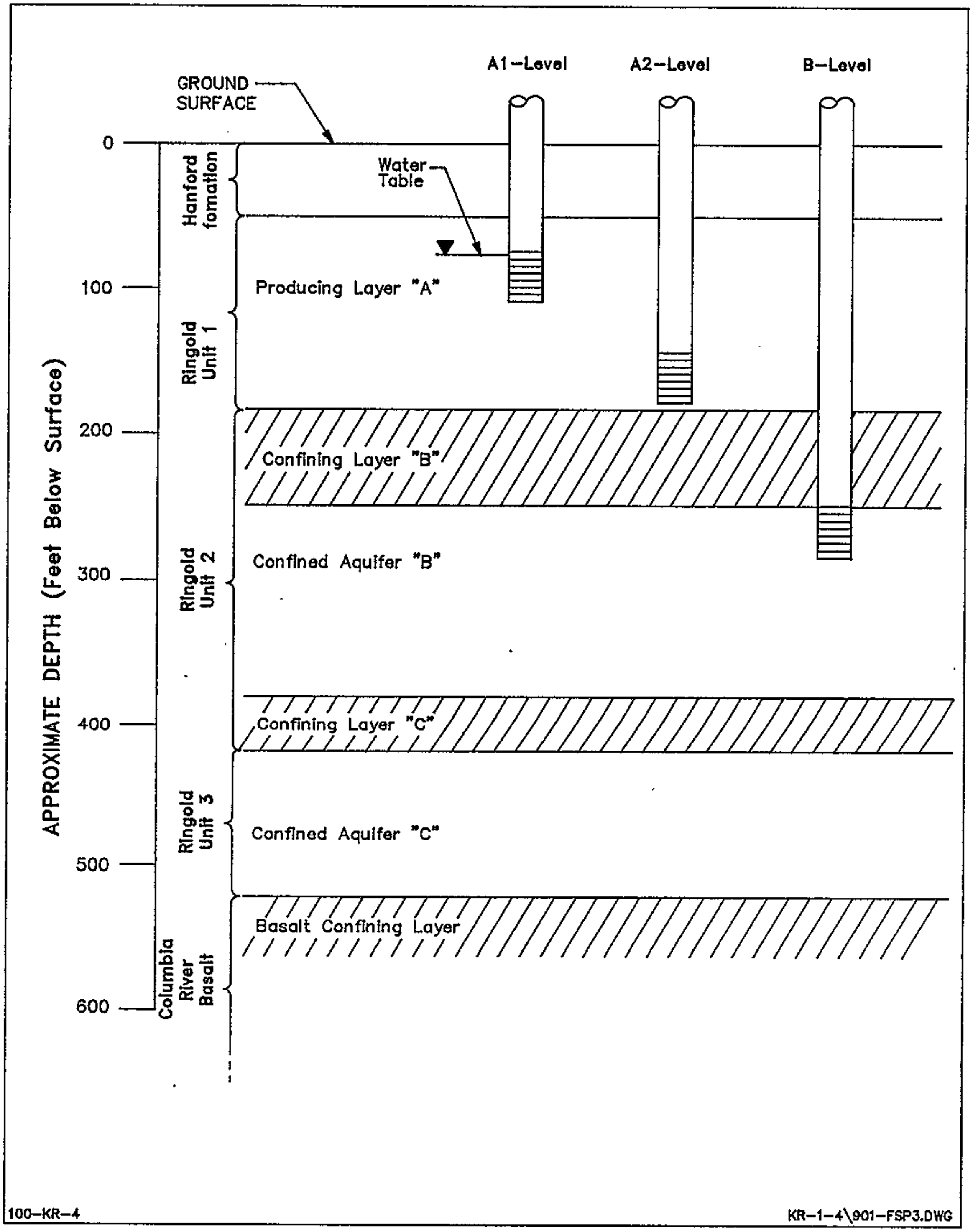

Figure FSP-3. Hydrostratigraphic Zones Targeted for Monitoring Well Completions at 100-K Area.

Sampling Methods--Several methods of sampling may be employed for sampling soils from monitoring well borings. Cable-tool drilling methods have been proposed for the monitoring wells from which samples will be taken. However, because of the natural variability of geologic materials, the most appropriate sampling equipment cannot be specified in advance. In general, sampling should be done in accordance with EII 5.2. Conditions may be encountered that require that less precise methods be used. For example, the formation may be too coarse to sample with any drive method, so cuttings may be collected from a discrete zone. This may limit the range of appropriate laboratory analyses for such a sample.

Field Screening--All soil samples obtained during the drilling will be screened with hand-held field instruments for alpha, beta, and gamma radiation, and VOCs (see Section 5.1.1.4). Details on surface radiation survey equipment and procedures will be developed in accordance with Westinghouse Hanford procedures in EII 1.2, or as specified in QAPP.

6.1.2.3 Borehole Logging. The purpose of the logging program is to provide a record of the geologic and hydrologic conditions encountered in the well borings, as well as other pertinent information. Both geologic and geophysical logging will be conducted.

6.1.2.3.1 Geologic Logging. Borehole geologic logs for each well boring will be constructed by a qualified geologist in accordance with EII 9.1. The geologic log will contain a description of the borehole lithology, observations of occurrences of water, changes in drilling rate, fluid return, sample intervals and similar observations. Blow counts will be recorded for the first 18 in. (46 cm) for each sampled interval and recorded in 6-in. (15-cm) increments on the borehole log, along with the hammer weight and length of the hammer fall.

6.1.2.3.2 Geophysical Logging. Geophysical logs will be run in the deepest boring at each well cluster location and at all proposed single well locations. Wells will be logged in accordance with EII 11.2. Upon the final decision of the well site geologist and/or hydrologist, the following geophysical instruments will be run:

- High-resolution spectral gamma (or natural gamma log)
- Gamma-gamma
- Neutron-epithermal neutron.

Other logs may be run at the discretion of the site geologist or hydrologist.

6.1.2.4 Well Completion. Wells will be installed after the boreholes are advanced to total depth. The design and specifications for these wells will be developed. Generally, it is proposed that the wells be completed with 4-in. (10-cm) ID #304 stainless-steel, flush-threaded casing, and wire-wrapped well screen. Wells will be installed according to EII 6.8.

Table FSP-4. Proposed Soil and Rock Chemical and Physical Analyses.
(sheet 1 of 2)

Laboratory analysis[a]	Parameter measured	Sample requirements/ limitations	Potential uses	Sample frequency	Method of collection[a]	References
Sieving	Particle size distribution of sand to gravel-sized particles	Individual particles must be disaggregated and unbroken to yield accurate results	Proxy for hydraulic parameters, ground water modeling, estimate sorption properties	Every 5 ft or change in lithology	H, D, S	ASTM 1972, Gee and Bauder 1986
Hydrometer	Particle size distribution of mud-sized particles (silt and clay)	<2-mm sediment size fraction	Characterize aquitards, ground water modeling, estimate sorption properties	All fine-grained intervals	H, D, S	ASTM 1972, Gee and Bauder 1986
Permeameter	Saturated hydraulic conductivity	Undisturbed/intact sedimentary core	Small-scale estimate of ground water travel time, check for aquifer tests, ground water modeling	Selected intervals	S	ASTM 1968, Klute and Dirksen 1986
Moisture content	Percentage water	Vadose zone samples	Identify perched water zones, vadose zone modeling	Every 5 ft or change in lithology above the water table	D, S	ASTM 1980
CO_2 gasometer[b]	Percentage $CaCO_3$ content	<2-mm sediment-size fraction	Identify aquitard, stratigraphic marker horizons, chemical interactions	Every 5 ft or change in lithology	H, D, S	Nelson 1986
Saturated paste[b] pH	pH	Bulk samples (~20 g)	Evaluate chemical interactions with contaminants	Every 5 ft or change in lithology	H, D, S	McLean 1986
Organic carbon[b] content	Organic carbon	<2-mm sediment-size fraction	Evaluate organic sorption capacity	Every 5 ft or change in lithology	H, D, S	Nelson and Sommers 1986
Ammonium acetate[b] extraction	Cation exchange capacity	<2-mm sediment-size fraction	Sorptive properties	Every 5 ft or change in lithology	H, D,	Rhoades 1986

Table FSP-4. Proposed Soil and Rock Chemical and Physical Laboratory Analyses.
(sheet 2 of 2)

Laboratory analysis	Parameter measured	Sample requirements/ limitations	Potential uses	Sample frequency	Method of collection	References
Petrography[b]	Mineral content/ concentration	Sand-sized fraction	Determine sorptive potential of primary mineral species, differentiate among hydrostratigrahic units	Every 5 ft or change in lithology	H, D, S	Kerr 1959
Soil[b] retention curves	Matric potential and moisture content	Vadose zone samples	Determine hydraulic conductivity	Every 5 ft or change in lithology	H, D, S	TBD
X-ray diffraction[b]	Clay mineral identification	Fine-grained sediments (silt and clay)	Sorptive characteristics, hydrostratigraphic unit identification	Selected fine-grained intervals	D, S	Drever 1973, Rich and Barnhisel 1977, MacEwan and Wilson 1980
Adsorption tests[b]	Chemical change from influent to effluent	<2-mm-sized fraction from representative sediment sample	Determine distribution coefficient for risk assessment and remedial alternatives	Selected representative sediment samples from below water table (analyze in conjunction with contaminated vadose zone samples)	D, S	Relyea et al. 1980, ASTM 1983a
Leaching[b]/ desorption tests	Release from contaminants from sediments	<2-mm-size fraction from representative sample or material from adsorption test	Determine distribution coefficient for risk assessment and remedial alternatives	Selected representative sediment samples from below water table (analyze in conjunction with contaminated vadose zone samples)	D, S	Gallagher 1979, ASTM 1988a
Bulk mass density[b]	Bulk porosity	Undisturbed/intact sedimentary core	Determine hydraulic parameters, ground water modeling	Selected intervals	S	ASTM 1986

[a] H = hard tool (may not be representative of the formation; D = drive-barrel drill method; S = split spoon drill method; C = diamond core.
[b] Well K-34B only.

Well development will occur in two stages. Stage 1 development will occur after the sand pack has been set and before installation of the annular seal. Additional filter sand will be added as the sand settles to meet well design criteria. Stage 2 development will occur a minimum of 24 h after completion of the well to allow the annular seals to set. Development will be conducted according to EII 10.4.

6.1.2.5 Well Surveying. Monitoring wells (including all existing wells) will be surveyed for both horizontal coordinates and vertical elevations. The horizontal plane survey accuracy will be ±1.0 ft (0.3 m). The elevation will be obtained at the ground surface and the top of the stainless-steel casing. The vertical control for the monitoring wells will be to a relative accuracy of 0.01 ft (0.003 m) to provide accurate indications of the ground water gradient.

6.1.3 Water Level Measurements

Water level elevations will be measured (to the nearest 0.01 ft [.003 m]) in the 100-K Area and vicinity wells on a monthly basis. These data will be used to evaluate seasonal water level trends and horizontal and vertical ground water gradients in the A1-, B2-, and B-level wells. Also, these data will help evaluate the hydraulic connection between the Columbia River and the shallow aquifer system. Pressure transducers will be placed in the wells along lines parallel and perpendicular to the Columbia River. The measurement intervals and period over which the measurements will be made will be determined as part of pre-RI activities.

6.1.4 Aquifer Testing

The purpose of conducting aquifer tests is to obtain information on the hydraulic properties of the various hydrostratigraphic horizons of concern. Aquifer test procedures are described in EII 10.1. Aquifer tests will consist of single well slug tests, rather than pumping tests, so that potentially contaminated water is not withdrawn from the wells. The water will be displaced in the well bore using compressed air or slugging rod. An additional slug method is to pump a well dry (instantaneously). This latter method can be conducted during the last stage of well development or during the purging of a well before sampling.

Slug tests may be conducted during the drilling of wells to determine hydraulic characteristics of confining units. Slug tests will also be conducted after drilling to total depths. Tests will be conducted in open holes where possible. If the hole will not stay open, tests will be completed through a well screen.

More sophisticated pumping tests (e.g., constant discharge) may be implemented as part of a subsequent phase of work.

The influence of the daily cycle of surface-water fluctuations on the rate of change in water levels (wave propagation) in ground water monitoring wells will be evaluated using the cyclic evaluation technique (Ferris 1952). Wave propagation analysis will consist of time-series analysis between the water levels of river-gauging stations in the Columbia River and water levels in several wells in the 100-K Area and vicinity. This technique may be used to provide additional information on aquifer transmissivity and storativity.

6.1.5 Ground Water Sampling

6.1.5.1 Sample Locations, Frequencies, and Procedures. Locations of wells to be sampled are shown in Figure 2 and Plate 2. Approximately 40 wells will be sampled in four rounds of sampling during Phase I. The spring and fall sampling will correspond to the seasonal high and seasonal low ground water levels.

The initial sampling round will be conducted no less than 2 wk following the completion of the final well. During the first round, approximately one-half of the wells will be sampled and will be analyzed for a comprehensive (extensive) list of chemical parameters (Tables FSP-2 and FSP-3). The other wells will be sampled and analyzed for parameters known to be present at concentrations in excess of guidelines using the less extensive (short) list (Tables FSP-2 and FSP-3). Following the first round of sampling, additional sampling will be conducted quarterly on 28 wells (see Table FSP-3).

6.2 SUBTASK 6c--LABORATORY ANALYSIS

Laboratory analyses will be performed on both soil and ground water samples. The analyses of the soil samples will include determination of the physical properties of the material (Table FSP-4). The ground water samples will be analyzed for water quality.

6.2.1 Soil Physical Properties

Soil physical properties to be tested for are presented in Table FSP-4 along with the associated testing methods to be used.

6.2.2 Water Chemical Properties

Samples will be analyzed for the organic, inorganic, and radioactive parameters listed in Table FSP-2. Analytical methods, container requirements, preservatives, and holding times for water samples are found in the QAPP, Attachment 1, Part 2.

Onsite field screening will be performed for VOCs and beta/gamma radiation.

7.0 TASK 7--AIR INVESTIGATION

The primary objective of the air investigation for the 100-KR-4 operable unit is to ensure the safety of the field personnel. Therefore, the air monitoring procedures are included in Attachment 2, HSP. Similarly, no compilation of meteorological data is envisioned. If necessary, real-time data (e.g., wind speed, wind direction, temperature) will be obtained from the Hanford meteorology station during sampling.

8.0 TASK 8--ECOLOGICAL INVESTIGATION

The ecological investigation for the 100-KR-4 operable unit will consist of a review of biological data developed and evaluated at other areas on the Hanford Site, supplemented by a focused, onsite riparian zone and aquatic biological survey.

8.1 SUBTASK 8b--FIELD ACTIVITIES

This subtask involves sampling species including reed canary grass, mulberry trees or willow shrubs, and various plants that may be exposed to humans.

Sampling sites for terrestrial biota will be at or near the sites where springs and seeps are sampled and show appreciable levels of contamination. An attractive nuisance study will be performed by a walkover study along the riparian habitat. This study will identify human-made structures or surface alterations that are attractive to wildlife and thus may increase their exposure to potential contamination. All sampling will be done in accordance with EII 5.3 (WHC 1989).

At each spring or seep sampling site, six samples of reed canary grass will be collected and composited. The sampling area around the spring may be enlarged to obtain sufficient quantities of grass.

Mulberry trees or willow shrubs may be present in the vicinity of spring sampling sites. Two samples consisting of leaves will be collected from each site where trees are present.

Walkover surveys will be conducted along the riparian zone to identify and locate plants that may be eaten by people boating on the Columbia River, particularly wild asparagus. If found, asparagus samples will be collected. If contaminated asparagus is found during the field investigation, immediate interim remedial action will be taken. Plants will be removed and locations marked for subsequent checking to prevent reestablishment.

Herbivores inhabiting the riparian zone can contribute to contaminant transfer through the food chain. Meadow mice and cottontail rabbits will be sampled if the plant sampling reveals elevated concentrations of contaminants in plant tissue.

8.2 SUBTASK 8c--LABORATORY ANALYSIS

A determination of the adequacy of existing data on the concentration of radionuclide uptake in vegetation to serve as a baseline will be a part of this task. If necessary, a baseline study will be initiated.

Composited samples of reed canary grass will be air dried and analyzed for radionuclides and selected heavy metals (chromium and mercury). Mulberry tree and/or willow shrub leaf samples will be analyzed for leaf-water tritium concentration. Asparagus samples will also be analyzed for radionuclides and selected heavy metals (chromium and mercury). Additional analytes may be added as a result of spring, seep, or sediment analyses.

9.0 TASK 9--OTHER INVESTIGATIONS

9.1 SUBTASK 9a--CULTURAL RESOURCES INVESTIGATIONS

A cultural resource investigation has identified the location of surficial archaeological or historical sites listed on or eligible for the National Register of Historic Places. However, additional archaeological sites may exist along the Columbia River immediately adjacent to the 100-K Area and will be part of this investigation.

The task will involve verifying the locations of known sites by reviewing available data on historic land uses by local Indian tribes as well as early 20th century land use by pioneer farmers and settlers. The focus of the investigation will be to determine whether archaeological resources are present at proposed drilling sites. A Class 3 field survey will be conducted by a qualified archaeologist as part of the initial RI field activities. The *Hanford Cultural Resource Management Plan* (Chatters 1989) will be followed during the review process. No RI work will be performed in this area of known sites before completion of this task.

9.2 SUBTASK 9b--TOPOGRAPHIC INVESTIGATIONS

A topographic base map will be developed at a scale that will allow the precision needed to show elevation contours at 1.5 ft (0.5 m) intervals, at a scale of 1:500. Mapping information will be shared or collected in concert with source operable unit investigations. State (Lambert) coordinates will be the primary reference grid with Hanford Site coordinates included. Facilities and sources will be included, corrected, and supplemented as appropriate, based on an inspection of aerial photographs of the 100-K Area.

10.0 STANDARD FIELD PROCEDURES

Standard field procedures used in the 100-K Area field activities will strictly follow Westinghouse Hanford document, *Environmental Investigations and Site Characterization Manual* (WHC 1989). Standard field procedures include sample designation, equipment and procedures, and handling.

10.1 SAMPLE DESIGNATION

Samples will be designated by a code, which includes a facility association code, type of sample with a sample number, depth, and analyses.

10.1.1 Facility Association or Well Number

Each code will begin with a code identifying the facility with which it is associated. The WIDS number will be used for those facilities assigned a number. For those facilities not assigned a WIDS number (e.g., process effluent pipelines and electric facilities), an abbreviation will be used followed by a number if more than one of these facilities is sampled. Ground water wells do not have a facility association, therefore, the well number will be used. Examples are provided below:

- 116KW3--cooling water retention basin waste unit 116-KW-3
- PEPX--the process effluent pipeline and number sampled
- ET#--electrical transformer and number sampled
- K36--well number.

10.1.2 Type of Sample with Sample Number

The code described above will be followed by a code describing the type of sample and sample number as indicated below:

- WS#--wipe sample and sample number
- SS#--soil sample and sample number
- LS#--liquid sample and sample number
- SLS#--sludge sample and sample number
- SG#--soil gas sample and sample number
- SPS#--split spoon sample and sample number
- CO#--core sample and sample number
- CT#--drill cuttings sample and sample number.

10.1.3 Depth of Sample

The code described above will be followed by the depth of the sample. If a depth range is sampled, then the greatest depth will be recorded, and if a surface sample is collected, then 00.0 will be recorded.

- ##.#--depth to the nearest tenth of a foot.

10.1.4 Analysis of Samples

The above codes will be followed by a code describing the required analyses or disposition (the number 2 will be appended for duplicate samples) of samples as follows:

- TCL--EPA target compound list
- TAL--EPA target analyte list
- PCB--PCBs
- SO--sulfamate and oxalate
- VOA--volatile organic analysis
- R--archive
- RAD--radionuclides of concern
- MS--metals and radiation analysis
- AS--nonmetallic ion analysis
- SVS--semi-volatile organic analysis
- TS--physical analysis.

Examples of the overall sample code are as follows:

- 116KW3-SS1-01.0-TCL--(soil sample number 1, obtained from the cooling water retention basin waste unit 116-KW-3 at a 1.0 ft (3 m) depth for target compound list analysis
- K36-SPS-12.0-TCL PCB--(split spoon sample obtained from well K36 at a maximum depth of 12.0 ft (4 m) for target compound list and PCB analysis.

If a Hanford Site or Westinghouse Hanford specific sample identification or coding system is developed before field activities, then the Hanford Site system will be used instead of the system described previously.

10.2 SAMPLE EQUIPMENT AND PROCEDURES

Details describing sampling equipment and procedures for most of the field sampling activities are described in the Westinghouse Hanford manual on environmental investigations (WHC 1989), and include the following:

- General Administrative Requirements
  - EII 1.2--Preparation and Revision of Environmental Investigations Instructions

- EII 1.4--Deviation from Environmental Investigations Instructions
- EII 1.5--Field Logbooks
- EII 1.6--Records Management
- EII 1.7--Indoctrination, Training, and Qualification
- EII 1.9--Work Plan Review
- EII 1.10--Identifying, Evaluating, and Documenting Suspect Waste Sites
- EII 1.11--Control and Transmittal of Laboratory Analytical Data

• Health and Safety

- EII 2.1--Preparation of Health and Safety Plans
- EII 2.2--Occupational Health Monitoring
- EII 2.3--Administration of Radiation Surveys to Support Environmental Characterization Work on the Hanford Site

• Equipment Maintenance

- EII 3.1--User Calibration of Health and Safety M&TE
- EII 3.2--Health and Safety Monitoring Instruments
- EII 3.3--Calibration Coordination

• Hazardous Materials

- EII 4.1--Nonradioactive Hazardous Waste Disposal
- EII 4.2--Interim Control of Unknown Waste

• Field Sampling

- EII 5.1--Chain of Custody
- EII 5.2--Soil and Sediment Sampling
- EII 5.3--Biotic Sampling
- EII 5.4--Decontamination of Drilling Equipment
- EII 5.5--Decontamination of Equipment for RCRA/CERCLA Sampling
- EII 5.6--Control of Geophysical Logging
- EII 5.7A--Hanford Geotechnical Sample Library Control
- EII 5.8--Ground Water Sampling
- EII 5.9--Soil-Gas Sampling
- EII 5.10--Sample Identification and Data Entry into HEIS Database
- EII 5.11--Sample Packaging and Shipping
- EII 5.12--Air Quality Sampling of Ambient and Downwind Air at Waste Sites
- EII 5.13--Drum Sampling
- EII 5.14--Drum Handling

• Drilling

- EII 6.1--Activity Reports of Field Operations
- EII 6.2--Ground Water Monitoring Wells Technical Oversight
- EII 6.4--Ground Water Resource Protection Well Maintenance
- EII 6.5--Plugging and Abandoning of Characterization Boreholes
- EII 6.6--Ground Water Well Characterization and Evaluation
- EII 6.7--Ground Water Well and Borehole Drilling
- EII 6.8--Well Completion

  - EII 6.9--Ground Water Well and Borehole Identification and Tracking
  - EII 6.10--Abandoning/Decommissioning Ground Water Wells

- Reclamation

  - EII 8.3--Remediation of Ground Water Wells

- Geology

  - EII 9.1--Geologic Logging

- Hydrology

  - EII 10.1--Aquifer Testing
  - EII 10.2--Measurement of Ground Water Levels
  - EII 10.3--Disposal of Well Construction/Development Waters
  - EII 10.4--Well Development Activities

- Geophysics

  - EII 11.1--Geophysical Logging
  - EII 11.2--Geophysical Survey Work

- Surveying and Mapping

  - EII 12.1--Surveying.

10.3 SAMPLE HANDLING

Field logs will be maintained to record all field observations and activities in accordance with EII 1.5, Field Logbooks (WHC 1989). Samples for laboratory analysis will be placed in containers and properly preserved in accordance with Section 4.0 of the QAPP. All samples for laboratory analysis will be transported under chain of custody in accordance with EII 5.1, Chain of Custody (WHC 1989), Section 5.0 of the QAPP, and EII 5.11, Sample Packaging and Shipping (WHC 1989).

10.4 DECONTAMINATION

Drilling and sampling equipment will be decontaminated in accordance with EIIs 5.4 and 5.5. Decontamination methods include scrubbing, wiping, flushing, and rinsing; steam cleaning or pressure washing may be used when a fluid collection system is in place. Decontamination fluids shall be collected and designated as unknown or nonregulated waste in accordance with EII 4.2.

REFERENCES

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ATTACHMENT 1

PART 2: QUALITY ASSURANCE PROJECT PLAN

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CONTENTS

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CONTENTS (cont)

FIGURE

TABLES

1.0 PROJECT DESCRIPTION

1.1 OBJECTIVE

The primary objective of the environmental investigations in the 100-KR-4 operable unit is to further define the extent and location of sources of radioactive, inorganic, organic, and other types of contaminants in the ground water system beneath the site. Data resulting from this investigation will be evaluated to determine the most feasible options for additional investigation, remediation or closure.

1.2 BACKGROUND INFORMATION

The 100-KR-4 operable unit is composed of ground water beneath the 100-K Area of the Hanford Site as shown in Figure QAPP-1. Detailed background information regarding the history and present use of the unit is provided in Chapter 2.0 of the 100-KR-4 operable unit work plan.

1.3 SCOPE AND RELATIONSHIP TO WESTINGHOUSE HANFORD QA PROGRAM

This quality assurance project plan (QAPP) applies specifically to the field activities and laboratory analyses to be performed as part of the investigation characterization of the 100-KR-4 operable unit. This QAPP is an element of the sampling and analysis plan (SAP) prepared specifically for this phase of investigation, and is prepared in compliance with the Westinghouse Hanford *Environmental Engineering, Technology, and Permitting Function Quality Assurance Program Plan*, WHC-EP-0383 (WHC 1990). This QAPP describes the means selected to implement the overall QA program requirements defined in the Westinghouse Hanford *Quality Assurance Manual*, WHC-CM-4-2 (WHC 1988a), as applicable the Comprehensive Environmental Response Compensation, and Liability Act of 1980 (CERCLA) RI/FS, while accommodating the specific requirements for project plan format and content agreed on in the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989). This QAPP incorporates the requirements of the proposed data quality strategy for Hanford Site characterization contained in McCain and Johnson (1990). Also contained in this QAPP is a matrix of procedural resources from the *Quality Assurance Manual* (WHC 1988a) and from Westinghouse Hanford *Environmental Investigation and Site Characterization Manual*, WHC-CM-7-7 (WHC 1988b) to support this QAPP. This QAPP is subject to mandatory review and revision before use on subsequent phases of the investigation. Distribution and revision control of this QAPP will be performed in compliance with quality requirement (QR) 6.0, Document Control and (QI) 6.1, Quality Assurance Document Control (WHC 1988a). The distribution of this QAPP shall routinely include all review and approval personnel indicated on the title page of this document and all other individuals designated by the Westinghouse Hanford technical lead. All plans and procedures referenced in this QAPP are available for regulatory review on request at the direction of the Westinghouse Hanford technical lead.

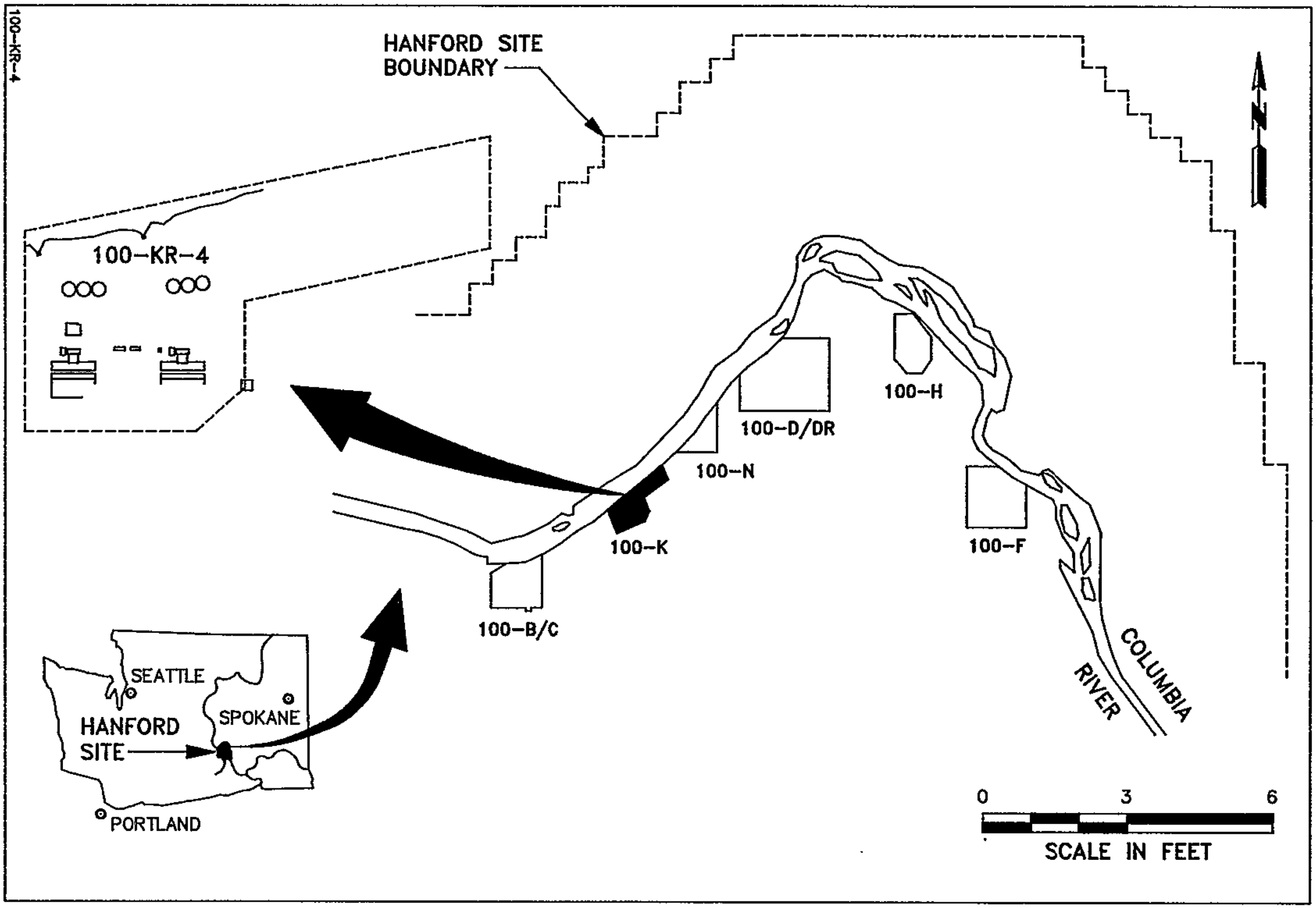

Figure QAPP-1. Northern Hanford Site and 100-K Area Operable Units.

1.4 SCHEDULE OF ACTIVITIES

The investigations that will be conducted in the 100-KR-4 operable unit will be subdivided into discrete phases and a number of individual tasks. This version of the QAPP applies specifically to the initial phase of the RI/FS.

Individual scopes for the RI tasks are briefly described in the following itemization; more detailed discussions are provided in Chapter 5.0 of the 100-KR-4 operable unit work plan. Procedures directly applicable to the tasks described herein are discussed in Chapter 4.0. Sample analyses will be conducted as described in Chapters 3.0 and 7.0.

- Task 2--Source investigations. Task 2 consists of a compilation of source data; an electromagnetic induction/magnetometer survey; a ground-penetrating radar survey; a soil-gas survey; a surface radiation survey; development of a topographic base map; preliminary sampling and analysis from soil, tank, and pipeline waste sources; evaluation of the integrity of the process effluent discharge pipeline; and various geodetic surveys.

- Task 3--Geologic investigations. Task 3 involves a compilation of existing data, surface mapping, and collection of geologic data obtained during drilling.

- Task 4--Surface water and sediment investigations. Task 4 consists of a shoreline survey, followed by sampling of springs and Columbia River water.

- Task 5--Vadose zone investigations. Task 5 consists of soil sampling and analysis in the vadose zone during drilling.

- Task 6--Ground water investigation. Task 6 consists of drilling and installing 23 monitoring wells. The well installation activities will be followed by ground water sampling.

- Task 7--Air investigations. Task 7 consists of a compilation of current meteorological data and field monitoring during the RI/FS field tasks.

- Task 8--Ecological investigations. Task 8 consists of a compilation of aquatic biological information and an onsite riparian and aquatic biological survey by qualified biologists.

- Task 9--Other investigations. Task 9 consists of other possible investigations deemed necessary as a result of operable unit data and findings.

- Task 10--Data evaluation. Task 10 is an evaluation of the data obtained in Tasks 2 through 9.

- Task 11--Baseline risk assessment. Task 11 is a study designed to identify and assess the risks associated with various potential corrective actions.

- Task 12--Preliminary RI report. Task 12 involves the preparation of the RI report that summarizes the preliminary characterization of the 100-KR-4 operable unit and includes summaries of all quality audit, surveillance, and instruction change activity that may have occurred during the course of the investigation.

2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

2.1 TECHNICAL LEAD RESPONSIBILITIES

The Environmental Engineering, and Technology Function of Westinghouse Hanford has primary responsibilities for conducting this investigation. Organizational charts are included in the project management plan. These charts define personnel assignments and individual Westinghouse Hanford field team structures applicable to the various types of tasks included in the Phase I RI.

External participant contractors or subcontractors shall be evaluated and selected for certain portions of task activities at the direction of the Westinghouse Hanford technical lead in compliance with procedures QR 4.0, Procurement Document Control; QI 4.1, Procurement Document Control; QI 4.2, External Services Control; QR 7.0, Control of Purchased Items and Services; QI 7.1, Procurement Planning and Control; and QI 7.2, Supplier Evaluation (WHC 1988a). Major participant contractor and subcontractor resources are listed in the project management plan.

2.2 ANALYTICAL LABORATORIES

An appropriate Westinghouse Hanford field sampling team will be responsible for screening all samples for radioactivity, and separating samples into two groups for further analysis. Samples with detectable levels of radioactivity using standard field survey equipment will be routed to a Westinghouse Hanford or another Hanford Site participant contractor laboratory equipped and qualified to analyze radioactive samples. Samples having no detectable radioactivity, as determined using standard field survey equipment, may be sent to onsite analytical laboratories. Samples showing detectable levels of radioactivity, measured with standard field equipment, will not be released to an offsite laboratory based on field measurements. These samples must be measured with laboratory radioanalytical equipment and released in accordance with Westinghouse Hanford procedures. All analyses shall be coordinated through the Westinghouse Hanford Office of Sample Management (OSM) and shall be performed in compliance with Westinghouse Hanford-approved laboratory QA plans and analytical procedures, subject to the surveillance controls invoked by QI 7.3, Source Surveillance and Inspection (WHC 1988a). For subcontractors or participant contractors, applicable quality requirements shall be invoked as part of the approved procurement documentation or work order, as noted in Section 4.1.2. Services of alternate qualified laboratories shall be procured for radioactive samples analysis if onsite laboratory capacity is not available and for the performance of split sample analysis at the Westinghouse Hanford technical lead's direction. If such an option is selected, the laboratory QA plan and applicable analytical procedures from the alternate laboratory shall be approved by Westinghouse Hanford before their use, as noted in Section 4.1.2.

2.3 OTHER SUPPORT CONTRACTORS

Procurement of all other contracted field activities except drilling, shall be in compliance with standard Westinghouse Hanford procurement procedures as discussed in Sections 2.1 and 4.1. All work shall be performed in compliance with Westinghouse Hanford approved QA plans/procedures, subject to the controls of QI 7.3, Source Surveillance and Inspection (WHC 1988a). Applicable QR shall be invoked as part of the approved procurement document or work order, as noted in Section 4.1.

3.0 QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENTS

Data quality objectives for ground water and surface water in the 100-KR-4 operable unit are summarized in Table QAPP-1. Analytical data will be obtained in two QA levels: screening quality data and validated data. A detailed discussion of these QA levels and their use is given in the proposed data quality strategy for Hanford Site characterization contained in McCain and Johnson (1990). See Table 4-1 in Chapter 4.0 of the work plan for a description of analytical levels

Screening methods are field or laboratory analyses often using the same or similar analytical methods as for validated data, but with less rigorous QA and quality control (QC) requirements. Screening methods are characterized by quick turnaround times and lower costs than validated methods. However, screening methods may not be compound specific and the data may be qualitative or only semiquantitative. During the RI, screening methods are used for two primary purposes: (1) defining the nature and extent of contamination over large areas or volumes of wastes where fully validated data are not required and where the expense and delay involved in obtaining only validated data would not be justified and (2) identifying samples for analysis by validated methods.

All screening methods must be verified by comparison with validated data, as required by Westinghouse Hanford EIIs (WHC 1988b). It is expected that screening methods for use at the 100-KR-3 operable unit will include screening for radionuclide contamination (Table QAPP-1). Job-site support laboratory analyses will be available or can be developed for use in screening water samples for some of the organic analytes (e.g., portable gas chromatography analyses). It is expected that data will be available from other operable units that indicate the correlations between the available screening methods and their associated validated methods.

Table QAPP-1. Precision, Accuracy, and Target Detection Limits for Analytes in Water (Sheet 1 of 3)

Parameter	Standard or Reference Method	Target Detection Limit	Precision % RPD[a]	Accuracy % Recovery
LEVEL III				
Metals analysis[b] (mg/L)				
Aluminum	6010	40	±35	±25
Arsenic	7060	2	±35	±25
Barium	6010	40	±35	±25
Beryllium	6010	1	±35	±25
Cadmium	6010	1	±35	±25
Chromium (total)	6010	2	±35	±25
Copper	6010	5	±35	±25
Iron	6010	20	±35	±25
Lead	7421	1	±35	±25
Magnesium	6010	3	±35	±25
Manganese	6010	3	±35	±25
Mercury	7471	0.04	±35	±25
Nickel	6010	8	±35	±25
Potassium	6010	1000	±35	±25
Selenium	7740	1	±35	±25
Silver	6010	2	±35	±25
Sodium	6010	1000	±35	±25
Strontium	6010	1000	±35	±25
Titanium	6010	10	±35	±25
Vanadium	6010	10	±35	±25
Zinc	6010	4	±35	±25
Ion analysis (mg/L)				
Ammonium	ASTM-D-1426	0.5 [c]	±35	±25
Chloride	EPA 300/ modified[d]	2.0	±35	±25
Cyanide	9010[b]	4	±35	±25
Fluoride	EPA-300/ modified[d]	0.5 mg/kg	±35	±25
Nitrate	EPA-300/ modified[d]	1.0 mg/kg	±35	±25
Phosphate	EPA-300/ modified[d]	5.0 mg/kg	±35	±25
Sulfate	EPA-300/ modified[d]	20.0 mg/kg	±35	±25
Sulfide	9030[b]	100	f	f

Table 1. Precision, Accuracy, and Target Detection Limits for Analytes in Water (Sheet 2 of 3)

Parameter	Standard or Reference Method	Target Detection Limit	Precision % RPD[a]	Accuracy % Recovery
Organic Analyses[b] (mg/L)				
Phosphate Pesticides	8140	0.3	±35	±25
Chlorinated Herbicides	8150	0.3	±35	±25
Organic Halides	9020	5	±35	±25
Organic Carbon	9060	1	±35	±25
Semivolatile Organics	8270	f	N/A	N/A
Volatile Organics	8240	f	N/A	N/A
Level IV				
Organic Scan				
Target compound list	CLP[g]	g	g	g
Inorganic Scan				
Target analyte list	CLP[g]	g	g	g
Level V				
Radionuclide Analyses[he] (pCi/ml)				
Americium-241	900.0	0.01	±10	±25
Carbon-14	C-01[i]	0.25	±10	±25
Calcium-41	j	--	--	--
Cobalt-60	901.1	0.04	±10	±25
Cesium-134	901.0	0.05	±10	±25
Cesium-137	901.0	0.05	±10	±25
Chromium-51	Cr-01[i]	0.20	±10	±25
Europium-152	901.1	0.10	±10	±25
Europium-154	901.1	0.10	±10	±25
Europium-155	901.1	0.10	±10	±25
Hydrogen-3	906.0	1.5	±10	±25
Iodine-129	902.0[k]	0.09	±10	±25
Nickel-63	j	0.10	±10	±25
Plutonium-238	907.0[l]	0.01	±10	±25
Plutonium-239	907.0[l]	0.01	±10	±25
Plutonium-240	907.0[l]	0.01	±10	±25
Strontium-90	905.0	0.02	±10	±25
Technetium-99	Tc-01[m]	0.03	±10	±25
Uranium-235	908.0[n]	0.01	±10	±25
Uranium-238	908.0[n]	0.01	±10	±25

Table 1. Precision, Accuracy, and Target Detection Limits for Analytes in Water (Sheet 3 of 3)

[a]RPD refers to relative percent difference.

[b]Methods specified are from Test Methods for Evaluating Solid Waste (SW-846) (EPA 1986).

[c]Typical detection limits are as specified in the associated American Society for Testing and Materials (ASTM) methods from 1988 Annual Book of ASTM Standards (ASTM 1987).

[d]Method is from Determination of Inorganic Anions in Aqueous and Solid Samples by Ion Chromatography (Lindahl 1984), modified from EPA Method 300.0.

[e]Analytical parameters presented are based on current information and will modified if necessary to meet project goals.

[f]Minimum requirements for method detection limits, precision, and accuracy will be method-specific.

[g]CLP methods, target detection limits, and minimum values for precision and accuracy shall be as specified in the statement of work (SOW) for CLP services.

[h]Unless noted analyses are from EPA "Prescribed Procedures for Measurement of Radioactivity in Drinking Water" PB80-224744

[i]Procedure from EPA Eastern Environmental Radiation Facility "Radiochemistry Procedures Manual" EPA 530/5-84-006

[j]No nationally recognized procedure available. Procedures for this isotope will be evaluated and may result in modification of the parameters listed.

[k]Procedure developed for analysis of Iodine-131

[l]Procedure and detection limits are for total plutonium alpha activity, isotopic analysis will require additional mass spectral analysis of alpha energy analysis

[m]Procedure from "EML Procedure Manual" HASL-300-Ed.25

[n]Procedure and detection limits are for total uranium activity, isotopic analysis will require additional mass spectral analysis or alpha energy analysis

Validated methods include contract laboratory program (CLP) routine analytical services (RAS) for identification and quantification of compounds on the target compound list (TCL) and target analyte list (TAL). However, CLP RAS may not provide sufficient detection limits for risk assessment and they may not be capable of identification and quantification of non-TCL and non-TAL substances that are important at the Hanford Site. At the Hanford Site, many of the contaminants of concern (particularly radionuclides) are not included on the TAL or TCL. Hence, modification of CLP RAS procedures, use of other standard procedures, or development of new laboratory procedures will be required to provide adequate analytical services. The CLP special analytical services will be used to develop special analytical procedures for non-TCL and non-TAL substances or compounds and improved detection limits, as needed.

As noted in Section 4.6 of *Data Quality Objectives for Remedial Response Activities - Development Process* (EPA 1987), universal goals for precision, accuracy, representativeness, completeness, and comparability (PARCC) cannot be practically established at the beginning of an investigation. Table QAPP-1 provided general guidelines and reference sources for method detection limits, precision, and accuracy available for each analyte of interest. Once methods are approved in compliance with standard procurement control procedures (as noted in Section 4.1), Table QAPP-1 shall be revised to reference approved detection limit, precision, and accuracy criteria as project requirements.

Goals for data representativeness are addressed qualitatively by the specification of sampling locations and intervals within the field sampling plan (FSP). Objectives for completeness for this investigation shall require that contractually or procedurally established requirements for precision and accuracy be met for at least 90% of the total number of requested determinations. Failure to meet this criterion shall be documented as a nonconformance, in compliance with QR 15.0, Control of Nonconforming Items; QI 15.1, Nonconforming Item Reporting; and QI 15.2, Nonconformance Report Processing (WHC 1988a); and shall be subject to corrective action measures as discussed in Section 13.0. Approved analytical procedures shall require they use of the reporting techniques and units specified in the EPA reference methods (EPA 1982) to facilitate the comparability of data sets in terms of precision and accuracy.

4.0 SAMPLING PROCEDURES

4.1 PROCEDURE APPROVALS AND CONTROL

4.1.1 Westinghouse Hanford

The Westinghouse Hanford procedures cited in this QAPP have been selected from the Quality Assurance Program Index included in the Westinghouse Hanford QAPP for CERCLA RI/FS activities. Selected procedures include EIIs from the *Environmental Investigations and Site Characterization Manual* (WHC 1988b), quality requirements (QR) and quality instructions (QI) from the *Westinghouse Hanford Quality Assurance Manual* (WHC 1988a) and operational health physics practice (WHC 1988). Procedure approval, revision, and distribution control requirements applicable to EII are addressed in EII 1.2, Preparation and

Revision of Environmental Investigation Instructions (WHC 1988b); requirements applicable to QI and QR are addressed in QR 5.0, Instructions, Procedures, and Drawings; QI 5.1, Preparation of Quality Assurance Documents; QR 6.0, Document Control; and QI 6.1, Quality Assurance Document Control (WHC 1988a). Other procedures applicable to the preparation, review, approval, and revision of Hanford Site analytical laboratories organization procedures shall be as defined in the various procedures and manuals identified in the Quality Assurance Program Index under criteria 5.00 and 6.00. All procedures are available for regulatory review on request.

4.1.2 Participant Contractor/Subcontractor

As noted in Section 2.1, participant contractor/subcontractor services shall be procured under the applicable requirements of QR 4.0, Procurement Document Control; QI 4.1, Procurement Document Control; QI 4.2, External Services Control; QR 7.0, Control of Purchased Items and Services; QI 7.1, Procurement Planning and Control; and/or QI 7.2, Supplier Evaluation (WHC 1988a). Whenever such services require procedural controls, requirements for submittal of procedures for Westinghouse Hanford review and approval prior to use shall be included in the procurement documentation or work order, as applicable. In addition to the submittal of analytical procedures, analytical laboratories shall be required to submit the current version of their internal QA program plans.

4.2 SAMPLING

4.2.1 Soil

All soil sampling shall be performed in accordance with EII 5.2, Soil and Sediment Sampling (WHC 1988b). All drilling activities shall be in compliance with EII 6.7, Ground Water Well and Borehole Drilling (WHC 1988b). All boreholes shall be logged in compliance with EII 9.1, Geologic Logging (WHC 1988b). Test pit sampling shall be in accordance with the auger or grab sample techniques described in EII 5.2. Sampling procedure applicable to individual Phase I tasks is shown in Table QAPP-2. Sample number, type location, and other site-specific considerations shall be as defined in Part 1--Field Sampling Plan. Documentation requirements are contained within individual EII and the Data Management Plan (DMP).

4.2.2 Ground Water and Surface Water

All ground water sampling shall be performed in accordance with EII 5.8, Ground Water Sampling (WHC 1988b). Surface water sampling methods are not specified in an EII. Westinghouse Hanford methods for surface water sampling will be developed before beginning the field investigation. Analytical methods and handling requirements for ground water and surface water samples are listed in Table QAPP-3.

Table QAPP-2. Sampling and Investigative Procedures for RCRA Facility Investigations in the 100-KR-4 Operable Unit. (sheet 1 of 3)

Procedure title or subject[a,b]		Task 2--Source investigations	Task 3--Geologic investigations	Task 4--Surface water and sediments investigations	Task 5--Vadose zone investigations	Task 6--Ground water Investigations	Task 7--Air Investigations	Task 8--Ecological investigations
EII.1.2	Preparation and Revision of Environmental Investigations Instructions	x	x	x	x	x	x	x
EII 1.4	Deviation from Environmental Investigations Instructions	x	x	x	x	x	x	x
EII 1.5	Field Logbooks	x	x	x	x	x	x	x
EII 1.6	Records Management	x	x	x	x	x	x	x
EII 1.7	Indoctrination, Training and Qualification	x	x	x	x	x	x	x
EII 1.8	Controlled Notebooks[c]	x	x	x	x	x	x	x
EII 2.1	Preparation of Hazardous Waste Operations Permits	x	x	x	x	x	x	x
EII 2.2	Occupational Health Monitoring	x	x	x	x	x	x	x
EII 3.1	User Calibration of Health and Safety Measuring and Test equipment	x	x	x	x	x	x	x
EII 5.1	Chain of Custody		x	x	x	x		x
EII 5.2	Soil and Sediment Sampling		x		x	x		
EII 5.3	Biotic Sampling[c]							x
EII 5.4	Decontamination of Drilling Equipment		x		x	x		
EII 5.5	Decontamination of Equipment for RCRA/CERCLA Sampling		x	x	x	x		x
EII 5.6	Control of Geophysical Logging	x			x	x		

Table QAPP-2. Sampling and Investigative Procedures for RCRA Facility Investigations in the 100-KR-4 Operable Unit. (sheet 2 of 3)

Procedure title or subject[a,b]		Task 2--Source investigations	Task 3--Geologic investigations	Task 4--Surface water and sediments investigations	Task 5--Vadose zone investigations	Task 6--Ground water investigations	Task 7--Air investigations	Task 8--Ecological investigations
EII 5.7A	Hanford Geotechnical Sample Library Control	x	x	x	x	x		
EII 5.8	Ground water Sampling			x		x		
EII 5.10	Sample Identification and Data Entry into HEIS Database		x	x	x	x		x
EII 5.11	Sample Packaging and Shipping		x	x	x	x		x
EII 5.12	Air Quality Sampling of Ambient and Downwind Air at Waste Sites						x	
EII 6.1	Activity Reports of Field Operations	x	x	x	x	x		
EII 6.2	Ground Water Monitoring Wells Technical Oversight				x	x		
EII 6.3	Preparation of Ground water Monitoring Well Construction Specifications				x	x		
EII 6.4	Ground Water Resource Protection Well Maintenance					x		
EII 6.5	Plugging and Abandoning of Characterization Boreholes				x			
EII 6.6	Ground Water Well Characterization and Evaluation					x		
EII 6.7	Ground Water Well and Borehole Drilling				x	x		
EII 6.8	Well Completion					x		
EII 6.9	Ground Water Well and Borehole Identification and Tracking[c]					x		
EII 7.1	Pest Control Administration and Operation	x	x	x	x	x	x	x

Table QAPP-2. Sampling and Investigative Procedures for RCRA Facility Investigations in the 100-KR-4 Operable Unit. (sheet 3 of 3)

Procedure title or subject[a,b]		Task 2--Source investigations	Task 3--Geologic investigations	Task 4--Surface water and sediments investigations	Task 5--Vadose zone investigations	Task 6--Ground water investigations	Task 7--Air investigations	Task 8--Ecological investigations
EII 10.1	Aquifer Testing					x		
EII 10.2	Measurement of Ground-Water Levels					x		
EII 11.1	Geophysical Logging[c]	x						
EII 11.2	Geophysical Survey Work	x						
EII 12.1	Surveying[c]	x		x	x	x		

[a]Procedures are latest versions of Westinghouse Hanford Company Environmental Investigations Instructions selected from WHC 1988b, unless otherwise indicated.
[b]Companion document is WHC 1988.
[c]In preparation.

Table QAPP-3. Analytical Methods and Handling Requirements for Ground Water and Surface-Water Samples. (sheet 1 of 2)

Description	Method[a]	Container requirement	Preservative	Holding time
Target compound list volatile organics	624	Three 40-mL amber glass	HCl pH<2 Cool 4 °C	14 d
Target compound list semivolatile organics	625	Two 80-oz amber glass	Cool 4 °C	7 d
Target compound list pesticides/polychlorinated biphenyls	608	One 80-oz amber glass	Cool 4 °C	7 d
Target analyte list metals	Contract Laboratory Program	One 1-L high-density polyethylene	HNO_3 pH<2 Cool 4 °C	6 mo
Chromium (hexavalent)	7196	One 250-mL high-density polyethylene	Cool 4 °C	24 h
				Radionuclides
Radionuclides	b	b	b	b
Oxalate	b	b	b	b
Sulfamate	b	b	b	b
Ammonia (as N)	350.2	One 1-L high-density polyethylene	H_2SO_4 pH<2 Cool 4 °C	28 d
Alkalinity	310.1	One 250-mL high-density polyethylene	Cool 4 °C	14 d
Biochemical oxygen demand	405.1	One 1-L high-density polyethylene	Cool 4 °C	48 h
Chemical oxygen demand	410.1	One 125-mL high-density polyethylene	H_2SO_4 pH<2 Cool 4 °C	28 d
Dissolved oxygen	NA	One 300-mL high-density polyethylene	None	Analyze immediately
Hardness	130.2	One 250-mL high-density	HNO_3 pH<2 Cool 4 °C	6 mo
Organic carbon	415.1	One 125-mL high-density polyethylene	HCl pH<2 Cool 4 °C	28 d
Nitrate[c]	353.2/353.3	One 25-mL high-density polyethylene	Cool 4 °C	48 h
Sulfate[c]	375.2/375.4	One 125-mL high-density polyethylene	Cool 4 °C	28 d
Chloride[c]	325.3	One 125-mL high-density polyethylene	None	28 d
Fluoride[c]	340.2	One 500-mL high-density polyethylene	None	28 d
Total dissolved solids[c]	160.1	One 125-mL high-density polyethylene	Cool 4 °C	7 d
Total suspended solids[c]	160.2	One 125-mL high-density polyethylene	Cool 4 °C	7 d
Phosphate (ortho)[c]	365.2/365.4	One 125-mL high-density polyethylene	Cool 4 °C	48 h
pH[c]	150.1	NA	NA	Field measurement

Table QAPP-3. Analytical Methods and Handling Requirements for Ground Water and Surface-Water Samples. (sheet 2 of 2)

Description	Method[a]	Container requirement	Preservative	Holding time
Bicarbonate[c]	403	One 125-mL high-density polyethylene	Cool 4 °C	14 d

[a]Standard methods are from EPA 1982.
[b]The methods, container requirements, preservatives, and holding times will be furnished by or approved by Westinghouse Hanford Company.
[c]May be analyzed from the same aliquot.
NA - Not applicable.

4.2.3 Sample Preparation and Handling

Sample container types, preservation requirements, preparation requirements, and special-handling requirements are defined in Part 1--Field Sampling Plan.

4.3 OTHER INVESTIGATIVE AND SUPPORTING PROCEDURES

Other procedures that will be required in this phase of the investigation are identified in Table QAPP-2, referenced to individual tasks as applicable. Documentation requirements shall be addressed within individual procedures and/or the DMP as appropriate. Analytical procedures required for Phase I of this investigation were listed in Table QAPP-1. All computer models developed shall be documented and verified in compliance with QI 3.2, Software Quality Assurance Requirements; or QI 3.3, Minimum Documentation for Existing Computer Software; as applicable.

4.4 PROCEDURE CHANGES

Should deviations from established EII be required to accommodate unforeseen field situations, they may be authorized in accordance with the requirements specified in EII 1.4, Deviation from Environmental Investigation Instructions (WHC 1988b). Documentation, review, and disposition of instruction change authorization forms are defined within EII 1.4. Other types of procedure change requests shall be documented as required by QR 6.0, Document Control; and QI 6.1, Quality Assurance Document Control. For radiation monitoring, deviations from established procedures must be approved in accordance with health physics technician procedures (WHC 1988). Field team leaders do not have the authority to change monitoring procedures or requirements.

5.0 SAMPLE CUSTODY

5.1 CHAIN-OF-CUSTODY PROCEDURES

All samples obtained during the course of this investigation shall be controlled as required by EII 5.1, Chain of Custody (WHC 1988b), from the point of origin to the analytical laboratory. Laboratory chain-of-custody procedures shall be reviewed and approved in compliance with the requirements of Section 4.1 of this QAPP, and shall ensure the maintenance of sample integrity and identification throughout the analytical process. At the direction of the technical lead, requirements for the return of residual sample materials after completion of analysis shall be in accordance with procedures defined in the procurement documentation to participant contractor/subcontractor laboratories. Chain-of-custody forms shall be initiated for returned residual samples as required by the approved procedures applicable within the participating laboratory. Results of analyses shall be traceable to original samples through the unique code or identifier specified in Part 1 FSP. All analytical results shall be controlled as permanent project quality records as required by QR 17.0, Quality Assurance Records (WHC 1988a); EII 1.6, Records Management (WHC 1988b); and the DMP.

5.2 SAMPLE FLOW PROCESS

Sample flow activity applicable to this investigation shall be coordinated with the Westinghouse Hanford OSM. All water samples shall be screened for beta and gamma radiation in compliance with approved field-screening procedures noted in Chapter 3.0. If elevated radiation levels are indicated, the inner core barrels, drive sampler, or other sampler assembly will be bagged and sealed on the site and delivered to an appropriate facility for sample extraction in a hot cell or other controlled area. Samples with detectable levels of radioactivity, obtained using standard field survey equipment, will be routed to a Westinghouse Hanford or Hanford Site participant contractor laboratory equipped and qualified to analyze radioactive samples. Samples having no detectable radioactivity, obtained using standard field survey equipment, may be sent to onsite analytical laboratories. Samples showing detectable levels of radioactivity, measured with standard field equipment, will not be released to an offsite laboratory based on field measurements. These samples must be measured with laboratory radioanalytical equipment and released in accordance with Westinghouse Hanford procedures. Alternate offsite subcontractor laboratories may be used for radioactive sample analysis at the Westinghouse Hanford technical lead's direction if onsite laboratory capabilities are inadequate. Samples with activity less than 200 cpm may be transported off the site to approved subcontractors or participant contractors for radionuclide and hazardous constituent analysis, as described in Chapters 3.0 (Table 3-1) and Chapter 7.0. All analyses shall be performed in compliance with Westinghouse Hanford-approved laboratory QA plans and analytical procedures, subject to standard Westinghouse Hanford surveillance controls, as noted in Section 4.1. Applicable quality requirements shall be invoked as part of the approved procurement documentation or work order.

6.0 EQUIPMENT CALIBRATION

Calibration of all Westinghouse Hanford measuring and test equipment, whether in existing inventory or purchased for this investigation, shall be controlled as required by QR 12.0, Control of Measuring and Test Equipment; QI 12.1, Acquisition and Calibration of Portable Measuring and Test Equipment (WHC 1988a); QI 12.2, Measuring and Test Equipment Calibration by User (WHC 1988a); and/or EII 3.1, User Calibration of Health and Safety Measuring and Test Equipment (WHC 1988b). Routine operational checks for Westinghouse Hanford field equipment shall be as defined within applicable EII or procedures; similar information shall be provided in Westinghouse Hanford-approved participant contractor or subcontractor procedures.

All calibration of laboratory equipment used for validated analysis shall be as required by the existing Contract Laboratory Program scope of work or as defined by applicable standard analytical methods, subject to Westinghouse Hanford review and approval.

7.0 ANALYTICAL METHODS

Analytical methods or procedures for each analytical level (screening or validated) identified in Table QAPP-1 shall be selected or developed and approved by the EPA before use. Compliance will conform with appropriate Westinghouse Hanford procedure and procurement control requirements. Table QAPP-1 provided general guidelines and reference sources for method detection limits, precision, and accuracy, as available, sorted by the required analytical level. Once individual laboratory statements of work are negotiated and procedures are approved in compliance with the requirements of Section 4.1, Table QAPP-1 shall be revised to include actual method references and approved detection limit, precision, and accuracy criteria as project requirements.

All analytical procedures approved for use in this investigation shall require the use of standard reporting techniques and units to facilitate the comparability of data sets in terms of precision and accuracy. All approved procedures shall be retained in the project quality records and shall be available for review on request, at the direction the Westinghouse Hanford technical lead.

8.0 DATA REDUCTION, VALIDATION, AND REPORTING

8.1 DATA REDUCTION AND DATA PACKAGE PREPARATION

All analytical laboratories (including field-screening laboratories) shall be responsible for preparing a report summarizing the results of analysis and for preparing a detailed data package that includes identification of samples, sampling and analysis dates, raw analytical data, reduced data, data outliers, reduction formulae, recovery percentages, QC check data, equipment calibration data, supporting chromatograms or spectrograms, and documentation of any nonconformances affecting the measurement system in use during the analysis of the particular group of samples. Data reduction schemes shall be contained within individual laboratory analytical methods or QA manuals, subject to Westinghouse Hanford review and approval as discussed in Section 4.1. The completed data package shall be reviewed and approved by the analytical laboratory QA manager (or field team leader for field-screening-type analysis) before submission to the Westinghouse Hanford technical lead for validation. The requirements of this section shall be included in procurement documentation or work orders, as appropriate, in compliance with the standard Westinghouse Hanford procurement control procedures noted in Section 4.1.

8.2 VALIDATION

Validation of the completed data package will be performed by qualified Westinghouse Hanford personnel or other qualified, independent, participant contractor or subcontractor or by qualified independent reviewers within the laboratory generating the analysis. Selection of qualified reviewers and assignment of validation responsibilities shall be at the discretion of the Westinghouse Hanford Technical Lead. Validation responsibilities shall be defined in procurement documentation or work orders, as appropriate. All Level III, IV, and V data will be validates as outlined below.

8.2.1 Screening Analyses--Report Preparation

Screening analyses for this investigation will be performed in accordance with procedures established for this investigation. Screening analyses shall include specific validation report preparation requirements that shall be reviewed and approved by Westinghouse Hanford before use, as noted in Section 4.1.

8.2.2 Validated Analyses (Standard Analytical Procedures)--Validation Report Preparation

All standard procedure analyses shall be validated in compliance with the guidelines established for CLP analysis. For organics analyses, validation reports shall be prepared documenting overchecks of the following areas, as recommended in *Laboratory Data Validation Functional Guidelines for Evaluating Organics Analyses* (EPA 1988a):

- Sample holding times
- Gas chromatograph/mass spectrometer tuning or adjustment requirements
- Initial and continuing calibration requirements
- Blank sample requirements
- Surrogate recovery requirements

- Matrix spike/matrix spike duplicate requirements
- Field duplicate requirements
- Internal standards performance requirements
- Target compound identification requirements
- Compound quantitation requirements and reported detection limits
- Any tentatively identified compounds, library search, and assessment requirements
- Overall data assessment requirements.

For inorganics analyses, validation reports shall be prepared documenting overchecks of the following areas, as recommended in *Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses* (EPA 1988b):

- Sample holding times
- Calibration requirements
- Blank sample requirements
- Interference check sample requirements
- Laboratory control sample requirements
- Duplicate sample analysis
- Matrix spike sample requirements
- Furnace atomic absorption QC requirements
- Inductively coupled plasma serial dilution requirements
- Field duplicate sample requirements
- Overall data assessment requirements.

8.2.3 Validated Analyses (Special Analytical Procedures)--Validation Report Preparation

All validation of radionuclide analyses (and, if required by screening analyses, other radioactive sample analyses) and other special validated analytical procedures shall be established as method-specific requirements, but shall follow the general guidance provided in Section 8.2.2.

8.3 FINAL REVIEW AND RECORDS MANAGEMENT CONSIDERATIONS

All validation reports and supporting analytical data packages shall be subjected to a final technical review by a qualified reviewer at the direction of the Westinghouse Hanford technical lead prior to submittal to the regulatory agencies or inclusion in reports or technical memoranda. All validation reports, data packages, and review comments shall be retained as permanent project quality records in compliance with EII 1.6, Records Management (WHC 1988b); QR 17.0, Quality Assurance Records (WHC 1988a); and the DMP.

9.0 INTERNAL QUALITY CONTROL

All analytical samples shall be subject to in-process QC measures in both the field and laboratory. Unless otherwise specified in the approved Part 1--Field Sampling Plan, the following minimum field QC requirements apply for validated analyses. These requirements are adapted from *Test Methods for Evaluating Solid Waste* (EPA 1986), as modified by the proposed rule changes included in the *Federal Register*, Volume 54, No. 13 (EPA 1989b).

- Field duplicate samples--For each shift of sampling activity under an individual sampling subtask, a minimum of 5% of the total collected samples shall be duplicated, or one duplicate shall be collected for every 20 samples, whichever is greater. Duplicate samples shall be retrieved from the same sampling location using the same equipment and sampling technique, and shall be placed into two identically prepared and preserved containers. All field duplicates shall be analyzed independently as an indication of gross errors in sampling techniques.

- Split samples--At the technical lead's direction, field or field duplicate samples may be split in the field and sent to an alternative laboratory as a performance audit of the primary laboratory. Frequency shall meet the minimum schedule requirements of Chapter 10.0.

- Blind samples--At the technical lead's direction, blind reference samples may be introduced into any sampling round as a performance and audit of the primary laboratory. Blind sample type shall be as directed by the Technical Lead; frequency shall meet the minimum schedule requirements in Chapter 10.0.

- Field blanks--Field blanks shall consist of pure deionized distilled water, transferred into a sample container at the site and preserved with the reagent specified for the analytes of interest. Field blanks are used as a check on reagent and environmental contamination, and shall be collected at the same frequency as field duplicate samples.

- Equipment blanks--Equipment blanks shall consist of pure deionized distilled water washed through decontaminated sampling equipment and placed in containers identical to those used for actual field samples. Equipment blanks are used to verify the adequacy of sampling equipment decontamination procedures, and shall be collected at the same frequency as field duplicate samples.

- Trip blanks--Trip blanks consist of pure deionized distilled water added to one clean sample container, accompanying a batch of containers shipped to the sampling activity. Trip blanks shall be returned unopened to the laboratory, and are prepared as a check on possible contamination originating from container preparation methods, shipment, handling, storage, or site conditions. In compliance with standard Westinghouse Hanford procurement procedures, requirements for trip blank preparation shall be included in procurement documentation or work orders to the sample container supplier and/or preparer.

Internal QC checks for validated analyses shall be as specified by the laboratory's existing Contract Laboratory Program contract, without modification, where applicable. The internal QC checks performed by analytical laboratories for other laboratory analyses shall meet the following minimum requirements:

- Matrix spiked samples--Matrix spiked samples require the addition of a known quantity of a representative analyte of interest to the sample as a measure of recovery percentage. The spike shall be made in a replicate of a field sample. Replicate samples are separate aliquots removed from the same sample container in the laboratory. Spike compound selection, quantities, and concentrations shall be described in the analytical procedures submitted for Westinghouse Hanford review and approval. One sample shall be spiked per analytical batch, or once every 20 samples, whichever is greater.

- QC reference samples and appropriate QA requirements--A QC reference sample shall be prepared from an independent standard at a concentration other than that used for calibration, but within the calibration range. Reference samples are required as an independent check on analytical technique and methodology and shall be run with every analytical batch, or every 20 samples, whichever is greater.

Other requirements specific to laboratory analytical equipment calibration are included in Chapter 6.0.

For field-screening gas chromatography analysis, at least one duplicate sample per shift shall be routed to a qualified laboratory as an overcheck on the proper use and functioning of field gas chromatography procedures and equipment. Duplicates shall be selected, whenever possible, from samples in which significant readings have been observed during field analysis.

The minimum requirements of this section shall be invoked in procurement documents or work orders in compliance with standard Westinghouse Hanford procedures as noted in Section 4.1.

10.0 PERFORMANCE AND SYSTEM AUDITS

Performance, system, and program audits are scheduled to begin early in the execution of this 100-KR-4 operable unit work plan and continue through work plan completion. Collectively, the audits address quality-affecting activities that include but are not limited to measurement system accuracy; onsite and offsite analytical laboratory services; field activities; and data collection, processing, validation, and management.

Performance audits of the accuracy of laboratory analysis are implemented in accordance with EII I.12, Laboratory Analysis Performance Audits. System audit requirements are implemented in accordance with QI 10.4, Surveillance. Surveillances will be performed regularly throughout the course of the work plan activities. Additional performance and system surveillances may be scheduled as a consequence of corrective action requirements or may be performed on request. All quality-affecting activities are subject to surveillance.

All aspects of inter-operable unit activities will also be evaluated as part of routine environmental restoration program-wide QA audits under the standard operating procedure requirements of the Westinghouse Hanford *Quality Assurance Manual* (WHC 1988a). Program audits shall be conducted in accordance with QR 18.0, Audits; QI 18.1, Audit Programming and Scheduling; and QI 18.2, Planning, Performing, Reporting, and Follow-Up of Quality Audits; by auditors qualified in accordance with QI 2.5, Qualification of Quality Assurance Personnel.

11.0 PREVENTIVE MAINTENANCE

All measurement and testing equipment used in the field and laboratories that directly affect the quality of the analytical data shall be subject to preventive maintenance measures that ensure minimization of measurement system downtime and corresponding schedule delays. For this investigation, such measures are confined to laboratory equipment because all field measurements are related either to the measurement of the sample interval or to the determination of radiological or other health and safety hazards. Laboratories shall be responsible for performing or managing the maintenance of their analytical equipment. Maintenance requirements, spare parts lists, and instructions shall be included in individual methods or in laboratory QA plans, subject to Westinghouse Hanford review and approval. Westinghouse Hanford field equipment shall be drawn from inventories subject to standard preventive maintenance procedures. Field procedures submitted for Westinghouse Hanford approval by participant contractors or subcontractors shall contain provisions for preventive maintenance schedules and spare parts lists to ensure minimization of equipment downtime.

12.0 DATA ASSESSMENT PROCEDURES

Characterization data from this phase of the 100-KR-4 operable unit investigation will be assessed as follows. As previously discussed in Section 8.0, analytical data shall first be compiled and reduced by the laboratory and validated in a manner appropriate for the individual analytical level. As part of Task 10, the validated data shall be evaluated against the source background data compiled in Task 2 and the information resulting from the various surveys conducted in Tasks 3 through 9. As discussed in Chapter 5.0 of the 100-KR-4 operable unit work plan and as directed by the Westinghouse Hanford technical lead, various statistical and probabilistic techniques may be selected for use in the process of data comparison and analysis. In all cases, however, the statistical methodologies and assumptions to be used in the evaluation shall be defined by written directions that are signed, dated, and retained as project quality records in compliance with EII 1.6, Records Management; and QR 17.0, Quality Assurance Records. Applicable directions shall be documented in the interim report produced at the conclusion of Task 9, for eventual consideration in the risk assessment performed in Task 11 and the report for this phase of the characterization of the 100-KR-4 operable unit produced in Task 12.

13.0 CORRECTIVE ACTION

Corrective action requests required as a result of surveillance reports, nonconformance reports, or audit activity shall be documented and dispositioned as required by QR 16.0, Corrective Action; QI 16.1, Trending/Trend Analysis; and QI 16.2, Corrective Action Reporting.

Other measurement systems, procedures, or plan corrections that may be required as a result of data assessment or routine review processes shall be resolved as required by governing procedures or shall be referred to the Westinghouse Hanford technical lead for resolution. Copies of all surveillance, nonconformance, audit, and corrective action documentation shall be routed to the project QA records on completion or closure.

Other measurement systems, procedures, or plan corrections that may be required as a result of routine review processes shall be resolved as required by governing procedures or shall be referred to the technical lead for resolution. Copies of all surveillance, nonconformance, audit, and corrective action documentation shall be routed to the project QA records upon completion or closure.

14.0 QUALITY ASSURANCE REPORTS

As stated in Sections 10.0 and 13.0, project activities shall be regularly assessed by performance and system auditing and associated corrective action processes. Surveillance, nonconformance, audit, and corrective action documentation shall be routed to the project QA records on completion or closure of the activity. A report summarizing all audit, surveillance, and instruction change authorization activity (see Section 4.4), as well as any associated corrective actions, shall be prepared for the Westinghouse Hanford technical lead by the QA coordinator at the completion of Phase I. Such information will become an integral part of Tasks 10 and 12 (see Section 1.0). The final report shall include an assessment of the overall adequacy of the total measurement system with regard to the data quality objectives of the investigation.

15.0 REFERENCES

40 CFR 122, Code of Federal Regulations, Title 40, Part 122, *EPA Administered Permit Programs: The National Pollutant Discharge Elimination System.*

Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order*, EPA Docket Number: 1089-03-120/Ecology Docket Number: 89-54.

EPA, 1982, *Methods for Chemical Analysis of Water and Wastes*, EPA-600/4-79/020, Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency, Cincinnati, Ohio.

EPA, 1983, *Interim Guidelines and Specifications for Preparation of Quality Assurance Project Plans, QAMS-005/80*, Office of Exploratory Research, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1986, *Test Methods for Evaluating Solid Waste*, SW-846, Third Edition, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1987, *Data Quality Objectives for Remedial Response Activities - Development Process*, OSWER Directive 9355.0-7B, EPA-540/G-87/003, Office of Emergency and Remedial Response and Office of Waste Programs, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1988a, *Laboratory Data Validation Functional Guidelines for Evaluating Organics Analyses*, Hazardous Site Evaluation Division, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1988b, *Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses*, Hazardous Site Evaluation Division, U.S. Environmental Protection Agency, Washington, D.C.

EPA, 1988c, *Contract Laboratory Program Statement of Work for Organics Analyses 288 and Inorganics 788*, U.S. Environmental Protection Agency, Washington, D.C.

Federal Register, 1989, "Part II, Environmental Protection Agency, 40 CFR Parts 260, 261, 262, 264, 265, 268, and 270, Hazardous Waste Management System; Testing and Monitoring Activities," *Federal Register*, Vol. 54, No. 13, January 23, 1989.

Ferris, J. G., 1952, "Cyclic Fluctuations of Water Levels as a Basis for Determining Aquifer Transmissibility," *International Geodetic and Geophysical Union, Science Hydrology General Assembly, Brussels, 1951*, Louvain, Belgium, pp. 148-155.

McCain, R. G. and W. L. Johnson, 1990, *A Proposed Data Quality Strategy for Hanford Site Characterization*, WHC-SD-EN-AP-023, Rev. No. 0, Westinghouse Hanford Company, Richland, Washington.

Resource Conservation and Recovery Act of 1976, as amended, Public Law 94-580, 90 Stat. 2795, 42 USC 6901 et seq.

WHC, 1988, *Operational Health Physics Practices Manual*, WHC-CM-4-12, Westinghouse Hanford Company, Richland, Washington.

WHC, 1988a, *Quality Assurance Manual*, WHC-CM-4-2, Westinghouse Hanford Company, Richland, Washington.

WHC, 1988b, *Environmental Investigations and Site Characterization Manual*, WHC-CM-7-7, Westinghouse Hanford Company, Richland, Washington.

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Attachment 2

HEALTH AND SAFETY PLAN

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CONTENTS

CONTENTS (cont)

FIGURES

TABLES

1.0 GENERAL CONSIDERATIONS AND REQUIREMENTS

1.1 INTRODUCTION

The purpose of this health and safety plan (HSP) is to establish standard health and safety procedures for Westinghouse Hanford employees and contractors engaged in remedial investigation (RI) activities in the 100-KR-4 operable unit. These activities will include drilling and sampling boreholes, well installation, and environmental sampling in areas of known chemical and radiological contamination.

All employees of Westinghouse Hanford or any other contractors who are participating in onsite activities in the 100-KR-4 operable unit shall:

- Read the HSP and attend a pre-job safety meeting to review and discuss the HSP
- Follow all health and safety procedures specified in this document and in the applicable hazardous waste operations permit (HWOP).

Each HWOP must be signed by all involved personnel. Employees are encouraged to bring any questions or concerns to the site safety officer. A mandatory 'tail-gate' safety meeting will be held before startup each day. Additional tailgate safety meetings or safety briefings will be held at any time it is deemed necessary by the site safety officer, the health physics technician, or the field team leader.

A HWOP be prepared for each work site, or group of similar work sites.

Each HWOP will be reviewed and approved by the 100-KR-4 operable unit technical lead, the field team leader, RI coordinator the site safety officer, Environmental Health and Pesticide Services Section, Industrial Safety and Fire Protection, Health Physics, the technical lead's manager, and the manager of other Westinghouse Hanford personnel with work responsibilities at the site, as related to the particular HWOP. The HWOP will also be reviewed and signed for concurrence by any non-Westinghouse Hanford contractor whose personnel are participating at the job site.

The levels of protection and procedures specified in this plan are based on the best available information and represent the minimum health and safety requirements to be observed at all times by Westinghouse Hanford employees and contractors while engaged in tasks associated with this project. The levels of protection stated in this HSP may differ from those required in the site-specific HWOP because of additional information not available at the time the HSP was written. In such cases the HWOP will take precedence over the HSP. Should any situation arise that is judged to be beyond the scope of the monitoring, personal protection, or decontamination procedures specified here or in the HWOP, work activities will stop and all personnel will withdraw from the exclusion zone as directed by the site safety officer, the health physics technician, and the field team leader. After review of the situation, the site safety officer will determine the need to upgrade the level of protection as specified in the HWOP or to revise the health and safety procedures for this activity.

1.2 DESIGNATED SAFETY PERSONNEL

The field team leader and site safety officer are responsible for site safety and health. Specific individuals will be assigned by project management on a task-by-task basis, and their names will be properly recorded before the task is initiated.

All activities onsite must be cleared through the field team leader. The field team leader has responsibility for the following:

- Allocating and administering the resources to successfully comply with all technical and health and safety requirements
- Verifying that all permits, supporting documentation, and clearances are in place (e.g., electrical outage requests, welding permits, excavation permit, HSP, sampling plan, radiation work permit, onsite/offsite radiation shipping records)
- Providing technical advice during routine operations and emergencies
- Informing the appropriate site management and safety personnel of the activities to be performed each day
- Coordinating resolution of any conflicts that may arise between radiation work permits and implementation of the HSP with Health Physics
- Handling of emergency response situations as may be required
- Conducting pre-job safety meeting and periodic tailgate safety meetings
- Interactions with adjacent building occupants and/or inquisitive public.

The site safety officer is responsible for implementing the HSP and HWOP at the site. The site safety officer shall:

- Monitor chemical, physical, and (in conjunction with the health physics technician) radiation hazards to assess the degree of hazard present; monitoring shall specifically include organic vapor detection, radiation screening, and confined space evaluation where appropriate
- Determine protection levels, clothing, and equipment needed to ensure the safety of personnel in conjunction with the Health Physics department

- Monitor performance of all personnel to ensure that the required safety procedures are followed
- Halt operations immediately, if necessary, because of safety or health concerns
- Conduct safety briefings as necessary.

The health physics technician is responsible for ensuring that all radiological monitoring and protection procedures are being followed as specified in the *Radiation Protection* manual (WHC 1988) and the appropriate radiation work permit. Westinghouse Hanford Industrial Safety and Fire Protection personnel will provide safety overview during drilling operations consistent with Westinghouse Hanford policy, as requested, and will provide technical advice. Also, downwind sampling for hazardous materials and radiological contaminants, respectively, and other analyses may be requested from appropriate contractor personnel as required.

The ultimate responsibility and ultimate authority for employee health and safety lies with the employee. Each employee is responsible for exercising the utmost care and good judgment in protecting personal health and safety and that of fellow employees. Should any employee observe a potentially unsafe condition or situation, it is the responsibility of that employee to immediately bring the observed condition to the attention of the appropriate health and safety personnel, as designated above. In the event of an immediately dangerous or life-threatening situation, the employee automatically has temporary 'stop-work' authority and the responsibility to immediately notify the field team leader or site safety officer. When work is temporarily halted because of a safety or health concern, personnel will exit the exclusion zone and meet at a predetermined place in the support zone. The field team leader, site safety officer, and health physics technician will determine the next course of action.

1.3 MEDICAL SURVEILLANCE

All Westinghouse Hanford personnel and contractors engaged in onsite activities on 100-KR-4 operable unit must have baseline physical examinations and be participants in the Westinghouse Hanford (or an equivalent) hazardous waste worker medical surveillance program.

Medical examinations will be designed to identify any preexisting conditions that may place an employee at high risk, and will verify that each worker is physically able to perform the work required by this work plan without undue risk to personal health. The physician shall determine the existence of conditions that may reduce the effectiveness or prevent the employee's use of respiratory protection. The physician shall also determine the presence of conditions that may pose undue risk to the employee while performing the physical tasks of this work plan using Level B personal protection equipment. This would include any condition that increases the employee's susceptibility to heat stress.

The examining physician's report will not include any nonoccupational diagnoses unless directly related to the employee's fitness for work required. Westinghouse Hanford hazardous waste worker medical surveillance records are maintained by the occupational health contractor in accordance with 29 CFR 1910.120,(f). The records are retained for the period specified and meet the criteria of the regulations. Westinghouse Hanford will provide employee access to medical records on request as required by law.

1.4 TRAINING

Before engaging in any onsite remedial investigation activities, each team member is required to have received 40 h of health and safety training related to hazardous waste site operations and at least 8 h of refresher training each year thereafter, as specified in 29 CFR 1910.120 (OSHA 1988a).

The field team leader and site safety officer will provide site-specific instructions regarding anticipated hazards, levels of protection, site monitoring, and operation of equipment as appropriate.

In addition, each inexperienced (never having performed site characterization) employee will be directly supervised by a trained, experienced person for a minimum of 3 days of field experience.

The field team leader and the site safety officer shall receive an additional 8 h of training (in addition to the refresher training discussed above).

1.5 TRAINING FOR VISITORS

For the purpose of this section, visitors are defined as any persons visiting the Hanford Site including, but not limited to, those engaged in surveillance, inspection, or observation activities who are not Westinghouse Hanford employees or Westinghouse Hanford contractors directly involved in the *Resource Conservation and Recovery Act* (RCRA)/*Comprehensive Environmental Response, Compensation and Liability Act* (CERCLA) facility investigation activities.

Visitors who must, for whatever reason, enter a controlled (either contamination reduction or exclusion) zone shall be subject to all of the applicable training, respirator fit testing, and medical surveillance requirements discussed in environmental investigations instruction (EII) 1.1 (WHC 1989).

All visitors shall be informed of potential hazards and emergency procedures by their escorts and shall conform to EII 1.1 (WHC 1989).

1.6 RADIATION DOSIMETRY

All visitors and site personnel engaged in onsite activities shall be assigned dosimeters according to the requirements of the radiation work permit applicable to the activity.

1.7 REQUIREMENTS FOR THE USE OF RESPIRATORY PROTECTION

All employees of Westinghouse Hanford and subcontractors who may be required to use air-purifying or air-supplied respirators must be included in a medical surveillance program and be approved for the use of respiratory protection by a Hanford Environmental Health Foundation (HEHF) physician or other licensed physician. Each team member must be trained in the selection, limitations, and proper use and maintenance of respiratory protection (existing respiratory protection training may be applicable to the 40-h training requirement).

Before using any negative-pressure respirator, each employee must be fit tested (within the past year) for the specific make, model, and size of respirator the individual will be using, according the Westinghouse Hanford fit testing procedures. Beards (including a few days' growth), large sideburns, or moustaches which may interfere with a proper respirator seal are not permitted.

Subcontractors must provide evidence to Westinghouse Hanford that their medical surveillance and respiratory protection programs comply with 29 CFR 1910.120 (OSHA 1988a) and 29 CFR 1910.134 (OSHA 1988b), respectively.

2.0 GENERAL PROCEDURES

The following personal hygiene and work practice guidelines are intended to prevent injuries and adverse health effects. A hazardous waste site poses a multitude of health and safety concerns because of the variety and number of hazardous substances present. These guidelines represent the minimum standard procedures for reducing potential risks associated with this project and are to be followed by all job-site employees <u>at all times</u>.

2.1 GENERAL WORK SAFETY PRACTICES

The following sections discuss work practices, personal protective equipment, personal decontamination, and emergency preparation.

2.1.1 Work Practices

The following work practices are required by 100-KR-4 operable unit personnel.

- Eating, drinking, smoking, taking certain medications, chewing gum and are prohibited within the exclusion zone. All sanitation facilities shall be located outside of the exclusion zone; decontamination is required before using such facilities.

- Personnel shall avoid direct contact with contaminated materials unless necessary for sample collection or required observation. Remote handling of equipment including casing and auger flights will be practiced whenever practical.

- While operating in the controlled zone, personnel shall use the 'buddy system' where appropriate, or be in visual contact with someone outside of the controlled zone.

- The buddy system will be used where appropriate for manual lifting.

- Requirements of Westinghouse Hanford radiation protection and radiation work permit manuals shall be followed for all work involving radioactive materials or conducted within a radiologically controlled area.

- Onsite work operations shall only be carried out during daylight hours, unless the entire control zone is adequately illuminated with artificial lighting. A new tour (shift) will operate the drilling rig after completion of each shift.

- Do not handle soil, waste samples, or any other potentially contaminated items unless wearing the protective gloves specified in the HWOP.

- Whenever possible, stand upwind of excavations, boreholes, well casings, drilling spoils, etc., as indicated by an onsite windsock.

- Stand clear of the trench during excavation. Always approach the excavation from upwind.

- Be alert to potentially changing exposure conditions as evidenced by such indications as perceptible odors, unusual appearance of excavated soils, or oily sheen on water.

- Do not enter a test pit trench greater than 4 ft (1.3 m) in depth unless in accordance with procedures specified in the HWOP.

- Do not <u>under any circumstances</u> enter or ride in or on a backhoe bucket, materials hoist, or any other similar device not specifically designed for carrying human passengers.

- All drilling operations members must make a conscientious effort to remain aware of their own and other's positions in regards to rotating equipment, cat heads, u-joints, etc. Drilling operations members must be extremely careful when assembling, lifting, and carrying flights or pipe to avoid pinch-point injuries and collisions.

- Tools and equipment will be kept off the ground whenever possible to avoid tripping hazards and the spread of contamination.

- Personnel not involved in operation of the drill rig or monitoring activities shall remain a safe distance from the rig as indicated by the field team leader.

- Follow all provisions of each site-specific hazardous work permit as addressed in the HWOP, including cutting and welding, confined space entry and excavation.

- Catalytic converters on the underside of vehicles are sufficiently hot to ignite dry prairie grass. Team members should not drive over dry grass that is higher than the ground clearance of the vehicle and should be aware of the potential fire hazard posed by catalytic converters at all times. <u>Never</u> allow a running vehicle to sit over dry grass or other combustible materials.

- Follow all provisions of each site-specific radiation work permit.

- Team members will attempt to minimize truck tire disturbance of all stabilized sites.

2.1.2 Personal Protective Equipment

The following discusses personal protective equipment required for 100-KR-4 operable unit personnel.

- Personal protective equipment will be selected specifically for the hazards identified in the HWOP. The site safety officer in conjunction with Health Physics and Industrial Safety and Fire Protection is responsible for choosing the appropriate type and level of protection required for different activities at the job site.

- Levels of protection shall be appropriate to the hazard to avoid either excessive exposure or additional hazards imposed by excessive levels of protection. The HWOP will contain provisions for adjusting the level of protection as necessary. These personal protective equipment specifications must be followed at all times, as directed by the field team leader, health physics technician, and site safety officer.

- Each employee must have available a hard hat, safety glasses, and substantial protective footwear to wear if specified in the HWOP.

- The exclusion zone around drilling or other noisy operations will be posted 'Hearing Protection Required.'

- Personnel should maintain a high level of awareness of the limitations in mobility, dexterity, and visual impairment inherent in the use of Level B and Level C personal protective equipment.

- Personnel should be alert to the symptoms of fatigue, heat stress, and cold stress and their effects on the normal caution and judgment of personnel.

- Life jackets must be worn and employees shall use the 'buddy system' for any activities over water (e.g., water column sampling of the Columbia River). Additional rescue equipment, as required by the Occupational Safety and Health Administration (OSHA) or the Washington State Industrial Safety and Health Administration (WISHA) standards for working over water will be available and used.

2.1.3 Personal Decontamination

The following personal decontamination procedures are required for Hanford Site personnel.

- The HWOP will describe in detail methods of personnel decontamination, including the use of contamination control corridors and step-off pads when appropriate.
- Thoroughly wash hands and face before eating or putting anything in the mouth, to avoid hand-to-mouth contamination.
- At the end of each work day or each job, disposable clothing shall be removed and placed in (chemical contamination) drums or plastic lined boxes or other containers as appropriate. Clothing that can be cleaned shall be sent to the Hanford Site Laundry.
- Individuals are expected to thoroughly shower before leaving the work site or Hanford Site if directed to do so by the health physics technician, site safety officer, or field team leader.

2.1.4 Emergency Preparation

The following describes available equipment, emergency preparation, and communication procedures.

- A multipurpose dry chemical fire extinguisher, a fire shovel, a complete field first-aid kit and a portable pressurized spray wash unit shall be available at every site where there is potential for personnel contamination.
- Prearranged hand signals or other means of emergency communication will be established when respiratory protection equipment is to be worn, as this equipment seriously impairs speech communications.
- The Hanford Fire Department shall be initially notified before the start of the site investigation project. This notification shall include the location and nature of the various types of field work activities as described in the 100-KR-4 operable unit work plan. A site location map shall be included in this notification.

2.2 CONFINED SPACE/TEST PIT ENTRY

The following procedures apply to the entry of any confined space which, for the purpose of this document, shall be defined as any space having limited egress (access to an exit) and the potential for the presence or accumulation of a toxic or explosive atmosphere. This includes manholes, certain trenches (particularly those through waste disposal areas), and all test pits greater than 4 ft (1.3 m) in depth in potentially contaminated soil. If confined spaces are going to be entered as part of the work operations, a hazardous work permit (filled out for confined space entry) must be obtained from Industrial Safety and Fire Protection.

The identified remedial investigation activities on 100-KR-4 operable unit should not require confined space entry. Nevertheless, the hazards associated with confined spaces are of such severity that all employees should be familiar with the safe work practices discussed below.

No employee shall enter a test pit or trench greater than 4 ft (1.3 m) in depth unless the sides are shored or laid back to a stable slope as specified in 29 CFR 1926.652 (OSHA 1988c) or equivalent state occupational health and safety regulations.

When an employee is required to enter a pit or trench 4 ft (1.3 m) or more in depth, an adequate means of access and egress, such as a slope of at least 2:1 to the bottom of the pit, or a secure ladder or steps shall be provided.

Before entering any confined space, including any test pit, the atmosphere will be tested for flammable gases, oxygen deficiency, and organic vapors. If other specific contamination, such as radioactive materials or other gases and vapors may be present, additional testing for those substances shall be conducted. Depending on the situation, the space may require ventilation and retesting before entry.

Any employee entering a confined or partially confined space must be equipped with an appropriate level of respiratory protection in keeping with the monitoring procedures discussed previously and the action levels for airborne contaminants (see the warnings and action levels in the HWOP).

No employee shall enter any test pit requiring the use of Level B protection, unless a backup person also equipped with a pressure-demand self-contained breathing apparatus (SCBA) is present. No backup person shall attempt any emergency rescue unless a second backup person equipped with a SCBA is present, or the appropriate emergency response authorities have been notified and additional help is on the way.

3.0 SITE BACKGROUND

The 100-K Area is located in the north central part of the Hanford Site and is situated along the southern shoreline of the Columbia River.

The 100-KR-4 operable unit is a ground water/surface water operable unit and is one of the four operable units in the 100-K Area and vicinity. The other three are source operable units (i.e., they contain sources of wastes and potential contamination): 100-KR-1, 100-KR-2, and 100-KR-3.

The 100-KR-4 operable unit encompasses all of the 100-K Area and vicinity, which is adjacent to the Columbia River. Major waste management facilities within the unit include spent fuel and cooling water basins, effluent cribs, an effluent trench, French drains, and burial grounds.

Currently there are several active facilities within the 100-K Area. They include the 105-KE and 105-KW fuel storage basins, which are storing spent fuel from the N reactor; the storage tanks adjacent to building 183.1-KE; building 1706-KE, where research and development efforts are being performed; a number of buildings used for site management; one pumphouse; one water treatment facility; and septic tanks and leach fields used for disposal of sanitary waste.

The *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989) lists 29 contaminant sources in the 100-KR-1, 100-KR-2, and 100-KR-3 operable units. Table HSP-1 locates and profiles the various units. Radioactive elements disposed in these operable units include activation and fusion products. An inventory of chemicals known to be disposed in waste sites in the 100-KR-4 operable unit are shown in Table HSP-2.

4.0 SCOPE OF WORK AND POTENTIAL HAZARDS

While the information presented in Section 3.0 is believed to be representative of the constituents and quantities of wastes at the time of discharge, the present chemical nature, location, extent, and ultimate fate of these wastes in and around the liquid disposal facilities are largely unknown. The emphasis of the RI in 100-KR-4 operable unit will be to characterize the nature and extent of contamination in the ground water, surface water and sediments of the Columbia River, and riparian biota.

4.1 POTENTIAL HAZARDS

Onsite tasks may involve invasive soil sampling and sampling procedures either directly in or immediately adjacent to areas known or suspected to contain potentially hazardous chemical substances, toxic metals, and radioactive materials.

Surface radiological contamination and fugitive dust will be the potential hazards of primary concern during noninvasive mapping and sampling activities.

Existing data indicate that hazardous substances that may be encountered during invasive sampling include radionuclides, heavy metals, and corrosives.

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Table HSP-1. Profiles of Facilities Within the 100-K Area.
(sheet 1 of 7)

Facility designation number	Associated structure	Description	Years in service	Process stream received or handled	Waste characteristics
116-KE-1	115-KE	Percolation crib	1955-1971	Condensate and other gas wastes from reactor gas purification systems; 40 X 40 X 26 ft	Avg beta-gamma $4.5(10^5)$ pCI/g (1981) Total Ci <240
116-KE-2	1706-KER	Percolation crib	1955-1971	From 1957 to 1964, site received wastes from cleanup columns in 1706-KER loop; 16 X 16 X 32 ft	Avg beta $4.3(10^3)$ pCi/g (1981) 100,000-kg sodium hydroxide Total 38 Ci
116-KE-3	105-KE basin	Percolation French drain	1955-1971	Site received wastes from 1706-KER loop cleanup columns or overflow from the 105-Ke fuel storage subdrainage Received waste from 105-KE fuel storage basins	No reported data
116-KE-5	Effluent piping	Test treatment or support facility (effluent piping)	1955-1971	Trace radioactive contamination in piping-mixed waste	No reported data
116-KE-6(A-P)	1706-KER	4 X 4 storage tanks	1986-Present	Mixed waste	
116-KW-1	115-KW	Percolation crib	1955-1971	Site received condensate and other wastewater from reactor gas purification systems; 40 X 40 X 26 ft	Beta-gamma-$4.5(10^5)$ pCi/g Pu-239/240 - 2.1 pCi/g Total 240 Ci
116-KW-2	105-KW	Percolation French drain	1955-1970	Low-level wastes from overflow out of 105-KW storage basin; 10 ft diam X 39 ft	

Table HSP-1. Profiles of Facilities Within the 100-K Area.
(sheet 2 of 7)

Facility designation number	Associated structure	Description	Years in service	Process stream received or handled	Waste characteristics
116-KW-4	Effluent piping	Test treatment or support facility (effluent piping)	1955-1970	Mixed waste-trace amounts of radioactive contamination remain in piping	No reported data
116-KE-3		Percolation French drain		Received waste from 105-KE fuel storage basins	Estimated data only
118-K-1	100-K	Burial ground	1955-1975	Mixed solid waste; contains numerous trenches	Total 14,000 Ci
118-K-2		Burial site	-	Sludge from 107 retention basin cleanup	No reported data
118-K-3		Filter crib	-	Unknown	
118-KE-1	105-KE	KE reactor building	1955-1971	Mixed waste, some highly radioactive; this unit consists of (1) reactor block with graphite moderator stack, biological and thermal shields, pressure tubes, safety and control systems, including irradiated moderator rods and 3X emergency moderator balls; (2) the fuel storage basin, used from 1975-1989; (3) contaminated portions of KE-reactor building 58,000 Ci of radionuclides, 167T Pb, 25,000 ft^3 of asbestos	---
118-KE-2	105-KE	KE Thimble cave	1955-1971	Used for storing radioactive rod tips pending later disposal; trace radionuclides remain	No reported data

Table HSP-1. Profiles of Facilities Within the 100-K Area.
(sheet 3 of 7)

Facility designation number	Associated structure	Description	Years in service	Process stream received or handled	Waste characteristics
118-KW-1	105-KW	KW reactor building	1955-1970	As with 105-KE (1) reactor block with shields; (2) irradiated fuel storage basin; (3) contaminated portions of 105-KW building, 51,000 Ci, 155T, 25,000 ft^3 of asbestos	---
118-KW-2	105-KW	KW thimble cave	1955- present	Used for storing radioactive rod tips; currently 4 rods plus other rod removal components; radiation at entrance with open door is 50 mrad/hr	No reported data
130-K-1	117-K	130-K-117 storage tank	?	Tank is filled with water and trace gasoline; soil column may be contaminated	No reported data
130-K-2	117-K	Storage tank	1955-1972	A small pool of motor oil remains in this tank; soil column may be contaminated	No reported data
130-K-3	182-K	Two 17,000-gal diesel oil storage tanks; tanks are drained	1955-1972	Fuel oil	No reported data
130-KE-1	115-KE	2,000-gal diesel fuel storage tank	1955-1971	Tank empty, 2,000-gal capacity	No reported data
130-KE-2	165-Ke	Fuel oil storage tanks	1955-1971	2,000 gal remain in concentrate tank; capacity of 1,650,000 gal used for firing 16 KE boilers	No reported data
130-KW-1	115-KW	Diesel fuel storage tanks	1955-1970	This tank is empty, with 2,000-gal capacity	Nonhazardous

Table HSP-1. Profiles of Facilities Within the 100-K Area.
(sheet 4 of 7)

Facility designation number	Associated structure	Description	Years in service	Process stream received or handled	Waste characteristics
130-KW-2	165-KW	Fuel storage tank	1955-1970	Identical to 130-KE-2	No reported data
130-KE-1	105-KE	Stack	1955-1971	Low-level waste/ top 125 ft of 300-ft stack demolished and remains in center of stack	No reported data
132-KW-1	105-KW	Stack	1955-1970	Identical to 132-KE-1	No reported data
1607-K4/124-KZ	1704-K, 1717-K	Septic tank	1955-present	Receives sanitary sewage from offices and maintenance shop; flow rate of 1,750 gal/d	No reported data
1607-K6/124-Kw-1	105-KW 115-Kw 165-KW	Septic tank	1955-present	Receives sanitary sewage from KW reactor building, 115-Kw gas recirculation building and power house flow estimated at 100 gal/d	No reported data
UN-100-K-1	105-KE	Leak from pickup chute area	NA	Mixed liquid waste from KE reactor storage basin; first detected during conversion to 100-N fuel storage in 1973-then 4-gal/d in April 1979 450-gal/h rate detected	No reported data
120-KE-1/ 100-KE*1	183.1-KE	Percolation reverse well; drywell 4 X 4 X 4 ft	1955-1971	Sulfuric acid sludge from the sulfuric acid storage tanks	200-kg mercury
120-KE-2/ 100-KE*2	183.1-KE	Percolation French drain; 3 ft diam Xj 3 ft	1955-1971	Sulfuric acid sludge from the sulfuric acid storage tanks	200-kg mercury
120-KE-3/ 100-KE*3		Percolation trench; 40 X 3 X 3 ft	1955-1970	Sulfuric acid sludge from the sulfuric acid storage tanks	700-kg mercury

Table HSP-1. Profiles of Facilities Within the 100-K Area.
(sheet 5 of 7)

Facility designation number	Associated structure	Description	Years in service	Process stream received or handled	Waste characteristics
120-KE-4	183.1-KE	Sulfuric acid storage tank (10,109-gal) tank has been drained and neutralized	1955-1971	Supply pipe from tank leaked to 183.1-building at NE corner	Leaked unknown quantity of sulfuric acid
120-KE-5	183.1-KE	Sulfuric acid storage tank (10,109-gal) tank has been drained and neutralized	1955-1971	No leakage reported	No leakage reported
120-KE-6	183.1-KE	Sodium dichromate storage tank removed in 1971; concrete base and piping remains	1955-1971	No leakage reported	Evidence of residual dichromate in the soil
120-KW-1/ 100 KW*2	183.1-KW	Percolation reverse well; drywell; 4 X 4 X 4 ft	1955-1970	Sulfuric acid sludge from the sulfuric acid storage tanks	200-kg mercury
120-KW-2/ 100 KW*2	183.1-KW	Percolation French drain; 3 ft dia X 3ft	1955-1970	Sulfuric acid sludge from the sulfuric acid storage tanks	200-kg mercury
120-KW-3	183.1-KW	10,109-gal sulfuric acid storage tank; tank has been drained and emptied	1955-1970	Supply pipe from tank to 183.1-KW building leaked	Leaked unknown quantity of sulfuric acid
120-KW-4	183.1-KW	10,109-gal sulfuric acid storage tank; tank has been drained and emptied	1955-1970	No leakage reported	No leakage reported
120-KW-5	183.1-KW	Sodium dichromate storage tank; removed in 1970; concrete base and piping remains	1955-1970	No documented releases	Evidence of residual dichromate in the soil

Table HSP-1. Profiles of Facilities Within the 100-K Area.
(sheet 6 of 7)

Facility designation number	Associated structure	Description	Years in service	Process stream received or handled	Waste characteristics
126-KE-2	183.1-KE	180,000-gal alum storage tank	1955-1971		Nonhazardous waste
126-KE-3	183.1-KE	180,000-gal alum storage tank	1955-1971		Alum is categorized as nonhazardous waste
128-K-1	100-K pit	Burning pit; 100 X 100 X 10 ft	1955-1971	Used for the disposal of nonradioactive combustible waste such as paint, office and chemical solvents	No reported data
1607-K1/124-K-1	1701-K 1720-K	Septic tank	1955-present	Sanitary sewage from the 1701-K and 1720-K buildings	Estimated daily flow of 350 gal
1607-K2/124-KE-1	183-KE	Septic tank	1955-present	Sanitary sewage from the 183-KW water treatment plant	Flow unknown
1607-K3	183-KW	Septic tank	1955-1970	Sanitary sewage	Waste amount unknown
1607-K5/124-KE-2	1706-KER 1706-K 165-KE 105-KE 115-KE	Septic tank	1955-present	Sanitary sewage	Estimated daily flow is 700 gal
116-K-1*	100-K crib	Effluent crib	1955-1955	Effluent from 107-KE and 107-KW retention basins at times of high activity due to fuel element failure	46 Ci 10,000 cpm 40-kg sodium dichromate

Table HSP-1. Profiles of Facilities Within the 100-K Area.
(sheet 7 of 7)

Facility designation number	Associated structure	Description	Years in service	Process stream received or handled	Waste characteristics
116-K-2*	100-K mile long trench	Effluent trench	1955-1971	Effluent from 107-KE and 107-KW retention basins at times of high activity due to fuel element failure	2,100 Ci 1,000-12,000 counts/min misc water treatment chemical additives
116-K-3	--	Outfall structure	1955-1971	Cooling water; discharge to river	No reported data
116-KE-4*	107-KE	Cooling water retention basins and adjacent area near tanks	1955-1971	Cooling water from 105-KE reactor	6.7 Ci sludge/fill ~2,000 counts/min
116-KW-3*	107-KW	Cooling water retention basins and adjacent area near tanks	1955-1970	Cooling water from 105-KW reactor	4,9 Ci sludge/fill ~2,000 counts/min
None	107-K retention basins	Burial ground	TBD	Sludge from 107-K basin cleanouts	TBD
None	1706-KE	Filter crib	TBD	Effluent from cooling loop studies and other R&D in 1706-KE	TBD

Table HSP-2. Chemical Waste Sites in 100-KR-4 (Jaquish and Mitchell 1988).

Waste site	Known chemical	Quantity (kg)
116-K-1	Sodium dichromate	40
116-K-2	Sodium dichromate Sulfuric acid Sulfamic acid Copper sulfate	300,000 10,000 10,000 500
116-KE-4	A,B	---
116-KW-3	A,B	---
116-K-3	A	---
130-KE-1	C	---
130-KW-1	C	---
116-KE-1	C	---
116-KE-2	Sodium hydroxide	100,000
116-KE-3	C	---
116-KW-1	C	---
116-KW-2	C	---
118-K-1	Metallic waste Construction waste Miscellaneous waste	100 100 1,000
1607-K1	C	---
1607-K2	C	---
1607-K3	C	---
1607-K4	C	---
1605-K5	C	---
1607-K6	C	---
130-KE-2	C	---
130-KW-2	C	---
130-K-1	C	---
130-K-2	C	---
UN-100-K-1	C	---
120-KE-1	C	---
120-KW-2	C	---
120-KE-3	C	---
120-KE-2	C	---
120-KW-5	C	---
120-KE-6	C	---
120-KW-1	C	---
128-K-1	C	---
130-K-3	C	---

A--Waste site did not dispose chemicals.
B--Chemical data not available for leaks.
C--No significant chemical inventory or unknown.

In addition, volatile organics may be associated with certain facilities where solvents were used or stored such as storage buildings, maintenance shops, and underground storage tanks.

As discussed previously, this project will involve the following:

- Drilling and well installation, and soil and ground water sampling in areas known or suspected to contain hazardous chemical substances, toxic metals, and radioactive materials
- River sediment sampling
- Spring and river water sampling
- Riparian zone sampling.

The degree of the potential occupational hazards is expected to be similar for each of the designated tasks. The likelihood of encountering hazardous chemical or radioactive substances will clearly be greatest during intrusions into and through the strata in the vicinity of the liquid waste disposal facilities.

Potential hazards include the following:

- External radiation (gamma, and to a lesser extent, beta) from radioactive materials in the soil
- Internal radiation from radionuclides present in contaminated soil entering the body by ingestion or through open cuts and scratches
- Internal radiation from inhalation of particulate (dust) contaminated with radioactive materials
- Inhalation of toxic vapors or gases such as volatile organics or ammonia
- Inhalation or ingestion of particulate (dust) contaminated with inorganic or organic chemicals, and toxic metals
- Dermal exposure to soil or ground water contaminated with radionuclides
- Dermal exposure to soil or ground water contaminated with inorganic or organic chemicals and toxic metals
- Physical hazards such as noise, heat stress, and cold stress
- Slips, trips, falls, bumps, cuts, pinch points, falling objects, other overhead hazards, crushing injuries, and other hazards typical of every construction-related job site
- Unknown or unexpected underground utilities.

4.2 ASSESSMENT AND MITIGATION OF POTENTIAL HAZARDS

The likelihood of significant exposure (100 mR/h or greater) to external radiation is remote and can be readily monitored and controlled by limiting exposure time, increasing distance, and employing shielding as required.

Internal radiation through inhalation or inadvertent ingestion of contaminated dust is a realistic concern and must be continuously evaluated by the health physics technician. Appropriate respiratory protection, protective clothing, and decontamination procedures will be implemented as necessary to reduce potential inhalation, ingestion, and dermal exposure to acceptable levels.

Exposure to toxic chemical substances through the dermal exposure route is not expected to pose a significant problem for the designated tasks, given the use of proper protective clothing. The appropriate level of personal protective clothing and respiratory protection will vary from soil sampling during drilling operations to sampling Columbia River water. In general, all activities conducted within an exclusion zone will require Level D-2. These levels of protection will be upgraded or downgraded as appropriate, based on real-time hazard evaluation and action levels.

Chemical exposure through inhalation of contaminated dust is not expected to pose a significant hazard because of the relatively low concentrations of chemicals in soil and low concentration of dust in the ambient air. Activities that result in high levels of airborne particulate (i.e., dusty operations) may require respiratory protection, dust control, or both.

Similarly, airborne concentrations of toxic gases or vapors are not expected to exceed applicable permissible exposure limits. As mentioned, however, the interactions and fate of these compounds are not well characterized. The site safety officer will periodically monitor airborne levels of toxic vapors and gases with direct reading field instruments selected for the anticipated hazards. A detailed monitoring plan, with frequency and location of measurements, specific chemical hazards, and type and mode of detection instrument to be used will be included in each HWOP or other health and safety documentation for that task. Air monitoring with direct reading instruments will be carried out continuously in the event of the detection of breathing zone concentrations greater than background levels. Respiratory protection will be employed as appropriate. Warning levels and action levels will be designated in the HWOP.

Should the work crew encounter an unanticipated underground utility, work shall be halted until the nature and status of the line is determined.

5.0 ENVIRONMENTAL AND PERSONAL MONITORING

The site safety officer or designee or delegate shall be present during work activities that present a high health and safety risk: their presence may not be necessary on all jobs, especially low risk and limited scoping tasks. Air quality monitoring equipment will be used during the field activities to quantify exposure of vapors and gases which pose risks. This equipment is intended to provide adequate warning and allow appropriate action to be taken to prevent harmful exposure to chemical and radiological contaminants released into the work environment. The air monitoring program will consist of monitoring air for contaminant vapor and gases in the vicinity of boreholes and breathing zones, and monitoring the general area for radiation. A health physics technician must be onsite as required and will observe the action levels and procedures specified in the radiation work permit and appropriate as low as reasonably achievable (ALARA) plans. Core samples will also be monitored to determine levels of radioactivity and occupational risks before actual sample collection. As indicated above, the decision to modify the level of protection will be made by the site safety officer, the health physics technician, and the field team leader. This decision will be based on, but not limited to the following:

- Interpretation of organic vapor, gas, and radiation detection instrument readings by health physics technician and health and safety personnel
- Visual observation such as wind, dust, or discoloration
- Unusual odors or those characteristic of contaminants
- Measurement with other sampling devices such as O_2 and explosive level meters
- Information specific to the individual sites (i.e., known or suspected chemical contaminants and levels of each)
- Physical characteristics of the work environment such as temperature and pH.

Air sampling may be required downwind of the referenced waste sites to monitor particulates and vapors before job startup. Siting of such sampling devices will be determined by health physics, site safety officer, and HEHF (if appropriate). Any time that personnel exposure monitoring, other than radiological, is required to determine exposure levels, it must be provided by HEHF. Discrete sampling of ambient air within the work zone and breathing zone will be conducted using a direct reading instrument, as specified in the HWOP, and other methods as deemed appropriate (e.g., pumps with tubes, O_2 meters). The following standards will be used in determining critical levels:

- *Radionuclide Concentrations in Air*, in DOE Order 5480.1B Chapter XI (DOE 1986)
- *Air Contaminants - Permissible Exposure Limits*, 29 CFR 1910.1000 (OSHA 1989)
- *Threshold Limit Values and Biological Exposure Indices for 1989-1990* (ACGIH 1990)
- *Occupational Safety and Health Standards*, 29 CFR 1910.120 (OSHA 1988a)

- *Pocket Guide to Chemical Hazards* (NIOSH 1985), recommended exposure limits for substances that do not have either a threshold limit value or a permissible exposure limit.

5.1 VOLATILE ORGANIC COMPOUNDS MONITORING

Although there is no record of disposal of volatile organic compounds in the 100-KR-4 operable unit, this section is included because it is the policy of Westinghouse Hanford to monitor for these compounds at all waste sites for safety reasons. The site safety officer shall have a direct reading instrument, as specified in the HWOP, onsite at all times and will establish 'background readings' upwind of any excavation, spoils pile, borehole, or the like.

Instruments used by the site safety officer will be calibrated according to EII 3.2, Health and Safety Monitoring Instruments (WHC 1989). Instruments used to monitor organic vapors and gases will be checked for calibration daily before and after use, according to the manufacturer's recommended or approved method, with certified calibration gas. Calibration information will be recorded in the field logbook at the time of calibration. Field instruments will be calibrated at field ambient temperature. Conditions such as unusual humidity or temperatures that may affect instrument performance will be recorded in the field logbook.

Each HWOP will contain action levels based on the hazards identified for that activity.

Warning and action levels will be based on criteria referenced in DOE-RL Order 5480.10A (DOE-RL 1988).

5.2 AIRBORNE RADIOACTIVE MATERIALS AND RADIATION MONITORING

An onsite health physics technician will monitor airborne radioactive contamination levels and external radiation levels. Action levels will be consistent with derived air concentrations and applicable guidelines as specified in the Westinghouse Hanford radiation protection manual, WHC-CM-4-10 (WHC 1988).

Appropriate respiratory protection shall be required when conditions are such that the airborne contamination levels may exceed an 8-h derived air concentration (i.e., the presence of high levels of uncontained, loose contamination on exposed surfaces or operations that may raise excessive levels of dust contaminated with airborne radioactive materials, such as excavation or drilling under extremely dry conditions).

Specific conditions requiring the use of respiratory protection because of radioactive materials in air will be incorporated into the radiation work permit. If, in the judgment of the health physics technician, any of these conditions arise, work shall cease until appropriate respiratory protection is provided.

6.0 PERSONAL PROTECTIVE EQUIPMENT

The level of personal protective equipment required initially at the site during excavation, drilling, and sampling activities will be specified in the unique HWOP for each job within the operable unit. Personal protective clothing and respiratory protection shall be selected to limit exposure to anticipated chemical and radiological hazards. Work practices and engineering controls as described in the HWOP will also be used to control exposure, because a personal protection equipment ensemble alone cannot protect against all hazards. The following guidelines will be used to specify personal protective equipment ensembles, based on the potential hazards determined in the HWOP: *Occupational Safety and Health Standards*, 29 CFR 1910.120 (OSHA 1988a) and *Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities* (NIOSH et al. 1985).

7.0 SITE CONTROL

The field team leader, site safety officer, and health physics technician are designated to coordinate access control and security on the site. A temporary exclusion zone will be established at each digging or drilling location. The exclusion zone will be clearly marked with radiation zone rope and 'Controlled Area' and/or 'Surface Contamination Area' signs or other appropriate signs or marker tape. If the exclusion zone is to be established for greater than 90 days, then chain, not rope, will be used. The size and shape of the exclusion zone will be dictated by the types of hazards expected, the climatic conditions, and specific drilling and sampling operations required. The ground surface of the area immediately around the drill hole, the corridors to the command post, and the decontamination area and escape route will be covered with appropriate material to reduce contamination of personnel and equipment when necessary. Exclusion zone boundaries will be increased or decreased based on results of field monitoring, environmental changes, or work technique changes. The site radiation work permit and the contractor's standard operating procedures for radiation protection will also dictate the boundary size and shape. Portable sanitation facilities shall be located outside of the control zone. No unauthorized person shall be allowed within the controlled zone and no authorized person shall be allowed within the exclusion zone unless equipped with the required level of personal protective equipment and respiratory protection. All personnel who enter the exclusion zone will be required to go through decontamination procedures (radiological and chemical) before leaving the zone. All team members must be surveyed for radioactive contamination upon leaving the exclusion zone if in a radiation zone, as required by the site safety officer, field team leader or health physics technician.

The onsite command post and staging area will be established near the exclusion zone on the upwind side, as determined by an onsite windsock, if physically possible. Exact location for the command post is to be determined just before start of work. Vehicle access, availability of utilities (power and telephone), wind direction, and proximity to sample locations should be considered in establishing command post location.

8.0 DECONTAMINATION PROCEDURES

Remedial investigation activities will require entry into areas of known chemical and radiological contamination. Consequently, it is possible that personnel and equipment could be contaminated with hazardous chemical and radiological substances.

During drilling and sampling activities at the site, potential sources of contamination include but are not limited to airborne vapors, gases, dust, mists and aerosols, splashes and spills, walking through contaminated areas, and handling contaminated equipment. All personnel who enter the exclusion zone will be required to go through the appropriate decontamination procedures upon leaving the zone. Decontamination areas shall be located upwind of the work area (based on the recorded predominant wind direction) and shall be sufficiently distant from the work site to allow for errant wind gusts, which may occasionally blow in from the work site. The procedures discussed below are intended to be compatible with EII 5.4, Decontamination of Drilling Equipment and EII 5.5, Decontamination of Equipment for RCRA/CERCLA Sampling (WHC 1989).

Decontamination procedures shall be consistent with Level B and Level C decontamination protocol. Specific decontamination procedures will provided in the HWOP. The following are examples of the equipment and facilities that may be used:

- Decontamination garbage/dirty equipment bags
- Decontamination pad/corridor cover (paper)
- Emergency response pressurized water tank with wand and adjustable spray nozzle
- Bagging and taping material
- Emergency water deluge and eyewash bottles
- Detergent, brush, and bucket
- Barrels
- Step-off pads
- Sponges, wipes, and rags
- Tables and stands.

8.1 PERSONNEL DECONTAMINATION

All personnel who access the exclusion and contamination reduction zones of the project will pass through appropriate decontamination at the end of any given work shift or any other time they leave the zones. A decontamination corridor will be established within the exclusion zone for each task of the campaign. Clothing that is disposable will be removed in such a manner that outer layers are removed first and placed in containers that will be sealed when full or at the end of each day. Nondisposable clothing (such as special work procedure) that can be cleaned will be removed, bagged, and sent to the laundry. All wash liquids used for decontamination purposes must be properly disposed of in accordance with applicable state and federal regulations. After removing outer protective clothing, each team member must undergo radiological survey upon proceeding to an uncontrolled area if required. If radioactive contamination is detected before leaving, the individual involved shall be escorted to an appropriate decontamination area by the health physics technician. At the health physics technician's discretion, nasal smears may be taken for counting/analysis. Health Physics Dosimetry shall also be notified, and the determination for further bioassay, if needed, will be made at that time. Site-specific radiation decontamination procedures will be provided in the radiation work permit or as specified by the onsite health physics technician.

8.2 EQUIPMENT DECONTAMINATION

Equipment decontamination methods will generally consist of washing or steam cleaning with a detergent/water or other decontamination solution, as specified in the Field Sampling Plan (FSP). Rinsing with a diluted nitric acid solution may be necessary to remove metal oxides and hydroxides. Field contamination of drilling equipment, where applicable, shall be performed within impoundments in the decontamination zone to ensure that all wash liquids are captured. All wash liquids used for decontamination purposes must be properly disposed of in accordance with applicable state and federal regulations.

Downhole drilling equipment shall be decontaminated before use on another borehole or as required to ensure the safety of personnel and prevent cross contamination of samples.

Equipment that is radiologically contaminated beyond the limits specified in the radiation work permit shall not be decontaminated in the field. Such equipment shall be transported to the 2705-T Building for decontamination before reuse.

8.3 SAMPLING AND MONITORING EQUIPMENT

All possible measures should be taken by personnel to prevent or limit the contamination of any sampling and monitoring equipment used. In general, air-monitoring instruments will not be contaminated by chemicals unless splashed or set down on contaminated areas. Any delicate instrument that cannot be easily decontaminated should be protected while it is being used by placing it in a bag and using tape to secure the bag around the instrument. Openings in the bag can be made for sample intake, electrical connections, etc. Personnel performing field maintenance procedures on air-monitoring instruments should be aware of the fact that instruments may become contaminated internally if air containing high concentrations of radioactive particulate is drawn through the instrument.

Foreign material, which collects within the probe tip and on the face of the lamp on the HNU[1] photoionization detector, may be chemically or radioactively contaminated, and should be handled appropriately when disassembling the probe or cleaning the lamp. A similar situation exists with the readout probe and metallic frit filters in the sampling line of the organic vapor analyzer. All instruments and equipment must be surveyed by the health physics technician for the purpose of radiological contamination control before removal from the radiation zone. Items with detectable levels of contamination must be controlled as radioactive material or controlled or regulated equipment.

Sampling devices require special cleaning and decontamination as detailed in EII 5.5, Decontamination of Equipment for RCRA/CERCLA Sampling (WHC 1989). When appropriate, disposable sampling equipment will be used to eliminate the need for decontamination liquids.

8.4 RESPIRATORY PROTECTION EQUIPMENT

Respiratory protection equipment will be specified in the HWOP. There is a high potential for airline hoses to become contaminated; whenever possible, hoses should be covered with plastic. If grossly contaminated, they may have to be discarded. Cleaning and decontamination of face pieces will be performed by the mask cleaning station (i.e., Hanford Site Laundry). Maintenance of special respiratory protection equipment (i.e., SKA PAK[2]) is performed by Personal Protective Equipment Unit in MO-412, 200 West Area.

8.5 HEAVY EQUIPMENT

All possible measures will be taken to prevent or limit the contamination of heavy equipment. Those parts of drilling equipment that become contaminated, such as auger flights, will be double bagged and taken to the 2705-T Building for decontamination before reuse to minimize personnel contamination potential and cross contamination of samples between boreholes.

9.0 CONTINGENCY AND EMERGENCY RESPONSE PLANS

The following procedures have been established to deal with emergency situations that might occur during drilling or sampling operations. As a general rule, in the event of an unanticipated, potentially hazardous situation as indicated by such signs as instrument readings, visible contamination, unusual or excessive odors, etc., team members shall temporarily cease operations and move upwind to a predesignated safe area. Any individual leaving a radiologically controlled area needs to be released by a health physics technician, even if that individual is going to the first

[1] HNU is a trademark of HNU Systems, Inc.

[2] SKA PAK is a trademark of Figgie International.

aid station (Figure HSP-1) or the hospital. If this cannot be accomplished, for whatever reason, the health physics technician must accompany the individual to the first aid station or the hospital.

A two-way radio will be operational and be used by the field team leader to maintain contact with the team's base station. When feasible, personnel in the exclusion zone will or site to site will maintain line-of-sight with the field team leader. Any failure of radio communications will require evaluation by the site safety officer and the field team leader to determine whether or not personnel shall leave the exclusion zone. Communications from rig to rig will also be provided so that the site safety officer or field team leader can respond to an emergency. In addition, a series of three 1-s horn blasts from a truck in the support zone is the emergency signal for all personnel to the leave the exclusion zone.

The following standard hand signals will be used in all cases:

Hand gripping throat	-	Out of air, can't breathe
Grip partner's wrist or both hands around waist	-	Leave area immediately
Hands on top of head	-	Need assistance
Thumbs up	-	OK, affirmative
Thumbs down	-	No, negative

The site safety officer is directly responsible for providing safety recommendations on the site to the site emergency coordinator. The site emergency coordinator for the 100-KR-4 operable unit drilling operations will be the field team leader or other person designated in the HWOP.

The site emergency coordinator will be responsible for the evacuation, emergency treatment, emergency transport of field personnel as necessary, and for the notification of the appropriate Hanford Site facility emergency response units and management staff.

Emergency communications will be maintained during all onsite field activities by two-way radio contact. If an emergency occurs, such as fire or explosion, all onsite personnel should exit the site in an upwind direction and assemble in a predesignated area. All emergency response actions for each job will be covered in the tailgate meeting with the HWOP. If an onsite injury occurs, team members should employ the procedures described in the following sections.

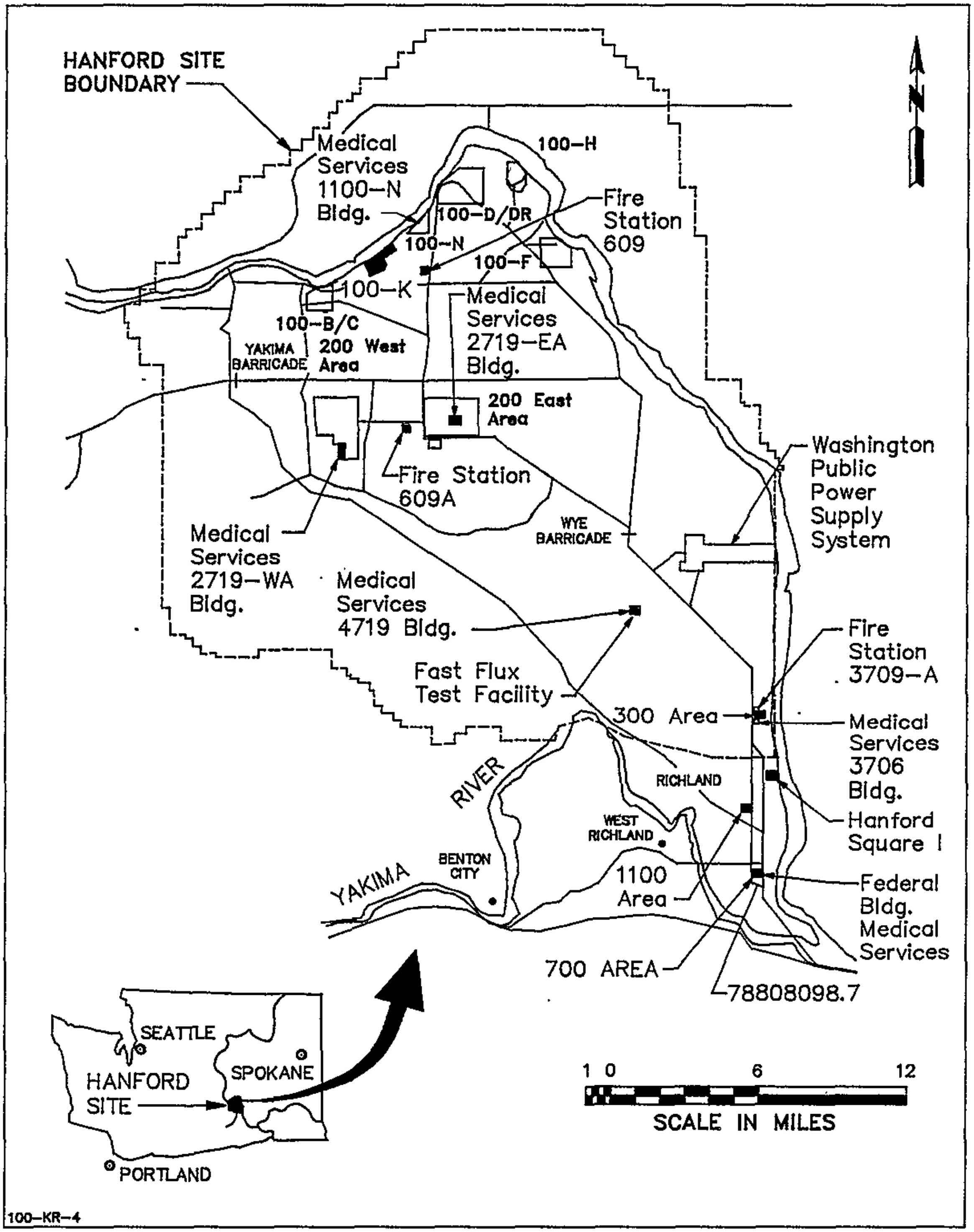

Figure HSP-1. Location of Hanford Emergency Facilities.

9.1 PROCEDURE FOR PERSONNEL INJURED IN THE EXCLUSION ZONE

Designated emergency response members of the field team shall be trained and certified in first aid and cardiopulmonary resuscitation. If an injury occurs, the designated team members will provide appropriate assistance. Only trained, certified personnel should attempt to give first aid. If able, the injured person should proceed through decontamination to the nearest available source of first aid.

Upon notification of a serious injury in the exclusion zone, the emergency signal of three 1-s horn blasts will be sounded. All site personnel will assemble at the decontamination line. The site safety officer and field team leader should evaluate the nature of the injury and the extent of decontamination possible before the injured person is moved to the support area. No person should reenter the exclusion zone until the cause of the injury is determined and measures taken to prevent recurrence.

9.2 PROCEDURE FOR PERSONAL INJURY IN THE SUPPORT AREA

Upon notification of an injury in the support area, the field team leader and the site safety officer will assess the situation. If the cause of the injury or absence of the person from the job site does not affect the performance or safety of site personnel, operations may continue, with initiation of first aid and summoning of medical assistance as discussed above. If the injury increases the risk to others, the emergency signal of three 1-s horn blasts will be sounded and all site personnel shall move to the decontamination area for further instructions. Activities onsite will stop until the hazardous condition (if any) is evaluated and reduced to an acceptable level.

9.3 PROCEDURES FOR FIRE AND EXPLOSIONS

The dry chemical fire extinguishers, which are required on all field vehicles, are effective for fires involving ordinary combustibles (e.g., wood, grass), flammable liquids, and electrical equipment. They are appropriate for small, localized fires such as a drum of burning refuse, small burning gasoline spill, or vehicle engine fire. No attempt should be made to use the provided extinguishers for well-established fires or large areas/volumes of flammable liquids.

In the case of fire, prevention is the best contingency plan. Smoking in the exclusion zone is strictly prohibited and smoking materials, where permitted, should be extinguished with care.

In the event of a fire or explosion, the following procedures are to be taken.

- Immediately notify site emergency personnel and the local fire department by contacting the Hanford Patrol by phone (811) or by radio (station 1) to relay message.

- If the situation can be readily controlled with available resources without jeopardizing personal health and safety or the health and safety of other site personnel, take immediate action to do so.

If the fire cannot be readily controlled, the following procedures are to be taken.

- Upon discovery of a fire or explosion onsite, the emergency signal of three 1-s horn blasts will be sounded and all site personnel will assemble upwind of the fire at the decontamination line. The fire department will be called and all personnel will move to a safe distance from the involved area. Again, based on the individual tailgate meetings, a decision to send all personnel immediately out of the exclusion area may be an option.

- Isolate the fire to prevent spreading, if possible.

- Clear the area of all personnel working in the immediate vicinity.

9.4 PROCEDURE FOR PERSONAL PROTECTIVE EQUIPMENT FAILURE

If any site worker experiences a failure or alteration of protective equipment that may jeopardize the level of protection provided by the equipment, that person and that person's buddy shall immediately proceed through decontamination and leave the exclusion zone. In the event of respiratory protection failure, the primary concern will be getting the person to breathable air, and decontamination will be secondary. Reentry shall not be permitted until the equipment has been repaired or replaced, or the conditions leading to the problem are adequately evaluated and corrected.

9.5 PROCEDURE FOR FAILURE OF OTHER EQUIPMENT

If onsite monitoring equipment fails to operate properly, the field team leader and site safety officer shall be notified and shall determine the effect of the failure on continuing operations. If the failure may compromise health and safety procedures or jeopardize the safety of personnel, all personnel shall leave the exclusion zone until the equipment is repaired or replaced.

9.6 EMERGENCY ESCAPE ROUTES

In the event that an emergency situation prevents exiting the exclusion zone by way of the decontamination area, exit the exclusion zone in any direction, preferably upwind, avoiding any barriers. Site-specific situations will be covered in more detail in the HWOP.

9.7 RESPONSE ACTION TO CHEMICAL EXPOSURE

Responses of this nature will be covered in the HWOP. Designated first aid field team members will be briefed on these procedures from the HWOP, and only those designated individuals will treat the exposed person. The site safety officer or field team leader should be notified of any chemical exposure incidents as soon as possible, so that appropriate actions may be taken to prevent further exposure.

9.8 EMERGENCY TELEPHONE NUMBERS

Local Resources:	Hanford Emergency Response Team	373-3800
Ambulance:	Hanford Fire Department will dispatch the ambulance	373-3800
Hospital:	Kadlec Hospital, Richland	946-4611
Police (Local or State):	Hanford Patrol	373-3800
Fire Department:	Hanford Fire Department	373-3800
Poison Control Center:		800-572-5842

EMERGENCY CONTACTS

Industrial Safety:	P. A. Wright (PNL) H. N. Bowers (WHC) T. H. Loratt (KEH)	376-1634 373-3948 376-4115
Health Physics:	J. R. Berry (PNL) J. B. Levine (WHC)	376-3057 373-1333
Field Team Leaders:	PNL or WHC	
Environmental Reporting:	W. J. Bjorklund (PNL) TBD (WHC)	376-4781 TBD

10.0 REFERENCES

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OSHA, 1988a, *Occupational Safety and Health Standards*, Title 29, Code of Federal Regulations, Part 1910.120, Occupational Safety and Health Administration, Washington, D.C.

OSHA, 1988b, *Occupational Safety and Health Standards*, Title 29, Code of Federal Regulations, Part 1910.134, Occupational Safety and Health Administration, Washington, D.C.

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Attachment 3

PROJECT MANAGEMENT PLAN

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CONTENTS

FIGURES

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1.0 INTRODUCTION

This project management plan (PMP) defines the administrative and institutional tasks necessary to support the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) remedial investigation/feasibility study (RI/FS) for the 100-KR-4 operable unit at the Hanford Site. This plan defines the responsibilities of the various participants, the organizational structure, and the project tracking and reporting procedures.

The U.S. Environmental Protection Agency (EPA), the State of Washington Department of Ecology (Ecology), and the U.S. Department of Energy (DOE) have entered into an agreement (the Hanford Federal Facility Agreement and Consent Order) for remedial actions and corrective activities on the Hanford Site (Ecology et al. 1989). An action plan, which implements and is an attachment to the agreement, defines EPA and Ecology regulatory integration and the methods and processes to be used to implement the agreement. This PMP is in accordance with the provisions of the action plan dated May 1989. Any revisions to the action plan that would result in changes to the project management requirements would supersede the provisions of this plan.

2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

2.1 INTERFACE OF REGULATORY AUTHORITIES AND THE U.S. DEPARTMENT OF ENERGY

The 100-KR-4 operable unit consists of inactive waste management units to be remediated under CERCLA. The EPA has been designated as the lead regulatory agency as defined in the Hanford Federal Facility Agreement and Consent Order. Accordingly, EPA is responsible for overseeing remedial action activity at this unit and ensuring that the applicable authorities of both EPA and Ecology are applied. The specific responsibilities of EPA, Ecology, and the DOE are detailed in the action plan.

2.2 PROJECT ORGANIZATION AND RESPONSIBILITIES

The project organization for implementing remedial activities at the Hanford Site is shown in Figure PMP-1. The following sections describe the responsibilities of the individuals shown in this figure.

Project Manager--The EPA, the DOE, and Ecology have each designated one individual as project manager, who will serve as the primary point of contact for all activities to be carried out under the agreement and the action plan. The responsibilities of the project managers are given in Section 4 of the action plan.

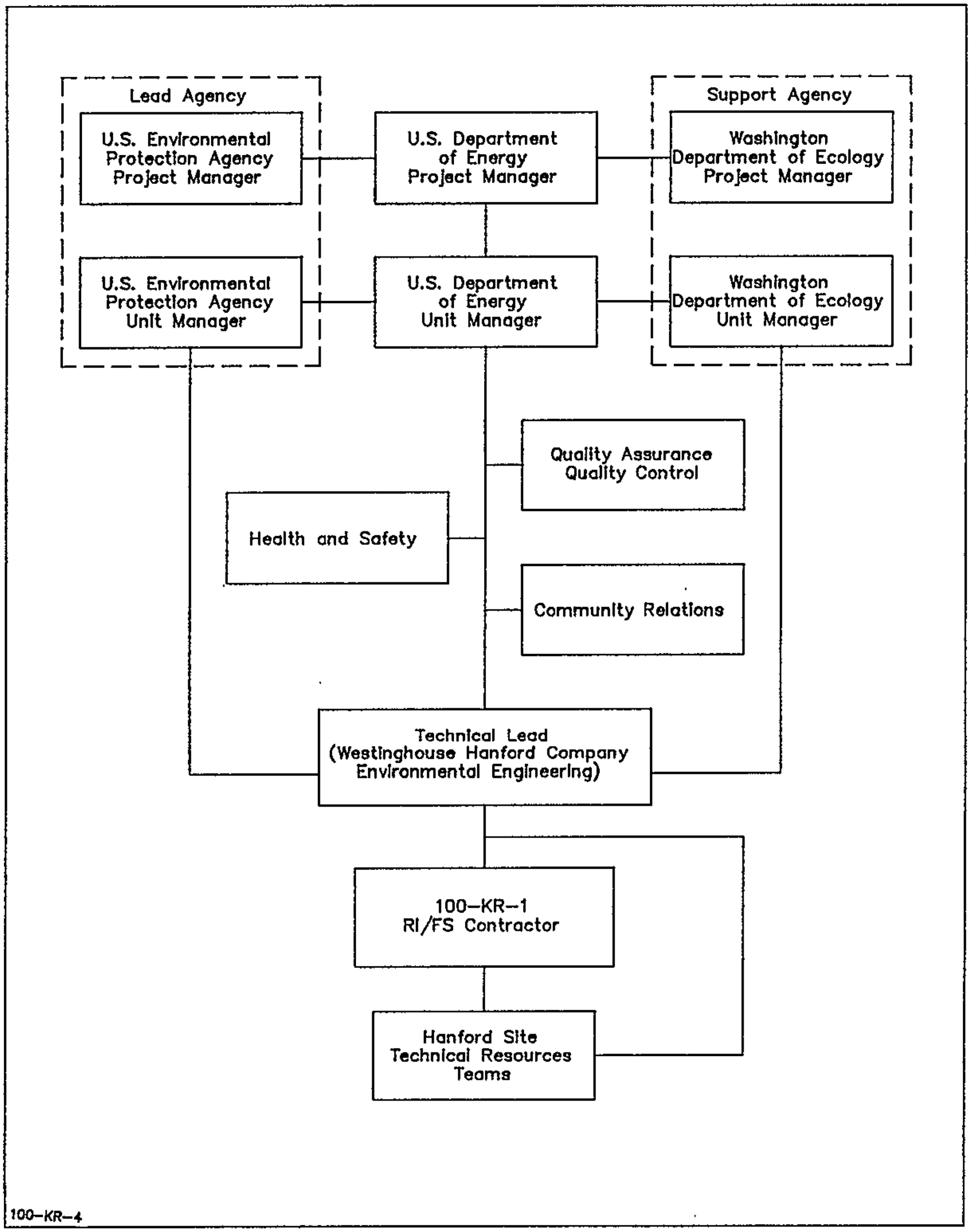

Figure PMP-1. Project Organization for Hanford Site RI/FS Projects.

Unit Manager--As shown in Figure PMP-1, the EPA, DOE, and Ecology will each designate an individual as a unit manager for the 100-KR-4 operable unit. The unit manager from EPA will serve as the lead unit manager. The EPA unit manager will be responsible for regulatory oversight of all RI/FS activities required for the 100-KR-4 operable unit.

The unit manager from Ecology will be responsible for making decisions related to issues for which the supporting regulatory agency maintains authority. All such decisions will be made in consideration of recommendations made by the EPA unit manager.

The unit manager from the DOE will be directly responsible for supervising the RI/FS activities at the 100-KR-4 operable unit. These responsibilities include maintaining and controlling the schedule and budget and keeping the EPA and Ecology unit managers informed as to the status of the RI/FS, particularly the status of agreements and commitments.

Quality Assurance Officer--The quality assurance officer is responsible for monitoring overall environmental restoration program activities through establishment of Hanford Site quality assurance auditing program controls that may be appropriately applied to all Resource Conservation and Recovery Act of 1976 (RCRA) feasibility investigations, RI/FS, and other Hanford Site environmental investigations. The quality assurance officer is specifically vested with the organizational independence and authority to identify conditions adverse to quality and to systematically seek effective corrective action.

Quality Coordinator--The quality coordinator is responsible for coordinating and monitoring performance of the quality assurance project plan requirements by means of internal surveillance techniques and by auditing, as directed by the quality assurance officer. The quality coordinator retains the necessary organizational independence and authority to identify conditions adverse to quality and to inform the technical lead of needed corrective action.

Health and Safety Officer--The health and safety officer is responsible for monitoring all potential health and safety hazards, including those associated with radioactive, volatile, and/or toxic compounds during sample handling and sampling decontamination activities. The health and safety officer has the responsibility and authority to halt field activities resulting from unacceptable nonradioactive health and safety hazards. In concert with the health physics technicians, the health and safety officer also has authority to halt field activities resulting from unacceptable radioactive safety hazards.

Technical Lead--The technical lead will be a designated person within the Westinghouse Hanford Environmental Engineering Group. The responsibilities of the technical lead will be to plan, authorize, and control work so that it can be completed on schedule and within budget, and to ensure that all planning and work performance activities are technically sound.

Remedial Investigation and Feasibility Study Coordinators--The RI and FS coordinators will be responsible for coordinating all activities related to the RI and FS, respectively, including data collection, analysis, and reporting. The RI and FS coordinators will be responsible for keeping the technical lead informed as to the RI and FS work status and any problems that may arise.

RI/FS Contractor--Figure PMP-1 also shows the organizational relationship of an offsite RI/FS contractor. If an offsite contractor is used to perform the RI/FS, the contractor would assume most responsibilities of the RI and FS coordinators, as described previously. In this instance, the contractor will be directly responsible for planning data collection activities and of analyzing and reporting the results of the data-gathering in the RI and FS reports. However, the Westinghouse Hanford Environmental Engineering Group coordinator would retain the responsibility for securing and managing the field sampling efforts of the Hanford Site technical resources. Figure PMP-2 shows a sample organizational structure for an RI/FS contractor team.

Hanford Site Technical Resources--The various technical resources available on the Hanford Site for performing the RI field studies are shown in Figure PMP-3. These resources will be responsible for performing data collection activities and analyses, and for reporting the results of specific technical activities related to the RI. Figures PMP-4 through -7 show the detailed organizational structure of specific technical teams. Internal and external work orders and subcontractor task orders will be written by the Westinghouse Hanford technical lead to use these technical resources, which are under the control of the technical lead. Statements of work will be provided to the technical teams and will include a discussion of authority and responsibility, a schedule with clearly defined milestones, and a task description including specific requirements. Each technical team will keep the RI coordinator informed on the RI work status performed by that group and of any problems that may arise.

3.0 DOCUMENTATION AND RECORDS

All RI/FS plans and reports will be categorized as either primary or secondary documents as described by Section 9 of the action plan. The process for document review and comment is also described in Section 9 of the action plan. Revisions, should they become necessary after finalization of any document, will be in accordance with the action plan. Changes in the work schedule, as well as minor field changes, can be made without having to process a formal revision. The process for making these changes are stated in the action plan. Administrative records, which must be maintained to support the Hanford Site CERCLA activities, will be in accordance with the action plan.

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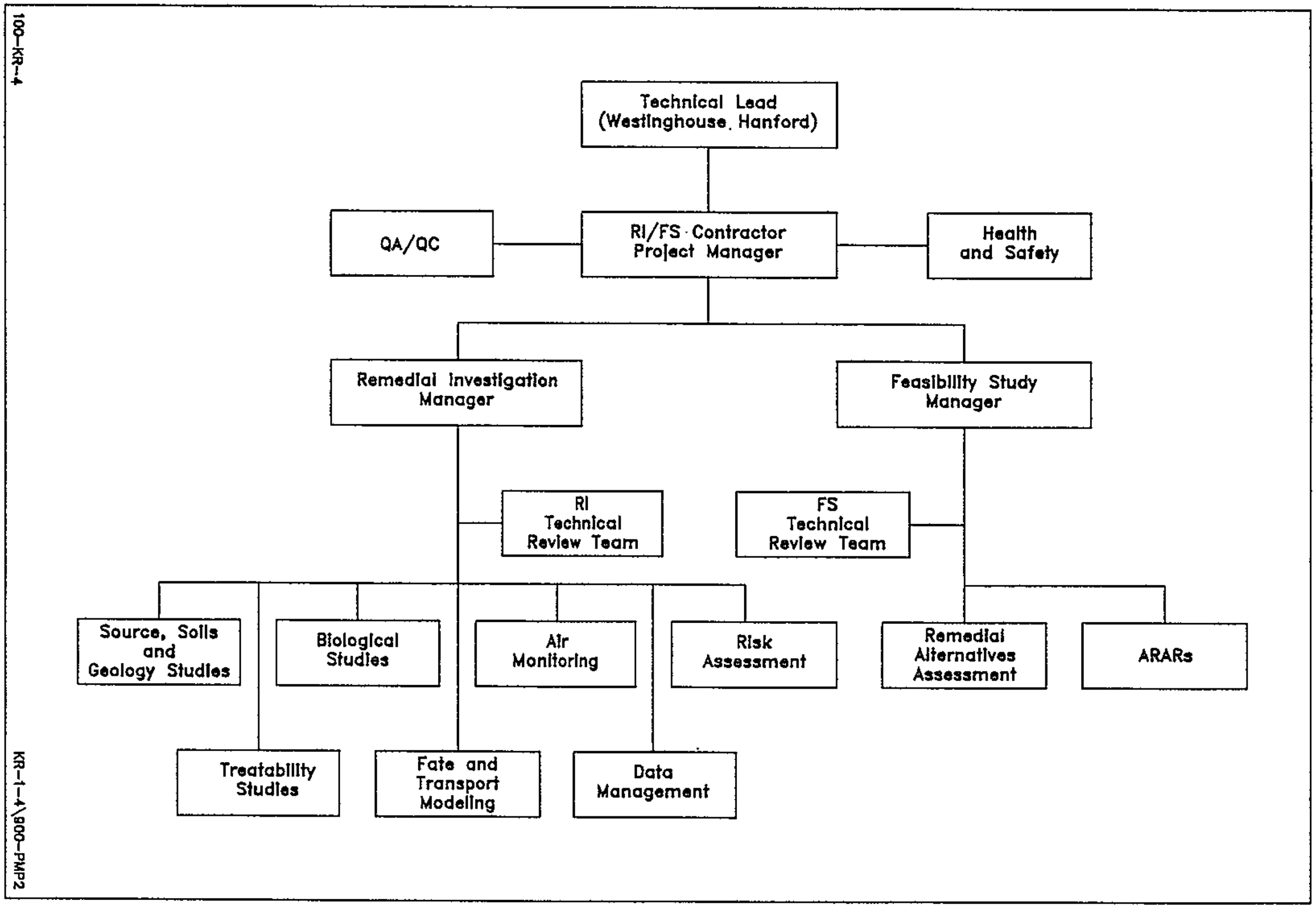

Figure PMP-2. Example Project Organization, 100-KR-4 RI/FS Contractor Team.

Subject/Activity	TECHNICAL RESOURCES	
	Remedial Investigation	Feasibility Study
Hydrology and geology	Westinghouse Hanford [a]/Geosciences; PNL [b]/Earth and Environmental Sciences Center	Westinghouse Hanford/ Geosciences
Toxicology and risk/endangerment assessment	Westinghouse Hanford/Environmental Technology; PNL/Earth and Environmental Sciences Center; PNL/Life Sciences Center	Westinghouse Hanford/ Environmental Technology
Environmental chemistry	Westinghouse Hanford/Geosciences; PNL/Earth and Environmental Sciences Center	Westinghouse Hanford/ Geosciences
Geotechnical and civil engineering	Westinghouse Hanford/Geosciences (Planning); PNL/Earth and Environmental Sciences Center	N/A
Geotechnical and civil engineering	N/A	Westinghouse Hanford/ Environmental Engineering PNL/Waste Technology Center
Ground water treatment engineering	N/A	Westinghouse Hanford/ Environmental Engineering PNL/Waste Technology Center
Waste stabilization and treatment	N/A	Westinghouse Hanford/ Environmental Engineering PNL/Waste Technology Center
Surveying	Kaiser Engineers Hanford	N/A
Soil and water	Westinghouse Hanford/Environmental Engineering/Environmental Field Services/Office of Sample Management and subcontractor; PNL/Earth and Environmental Services Center/Materials and Chemical Services Center	N/A
Drilling and well installation	Westinghouse Hanford/Geosciences/ Environmental field services; Kaiser Engineers	N/A
Radiation protection	Westinghouse Hanford/Health Physics	N/A

[a] Westinghouse Hanford = Westinghouse Hanford Company
[b] PNL = Pacific Northwest Laboratory

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Figure PMP-3. Hanford Site Technical Resources for Conducting RI/FS.

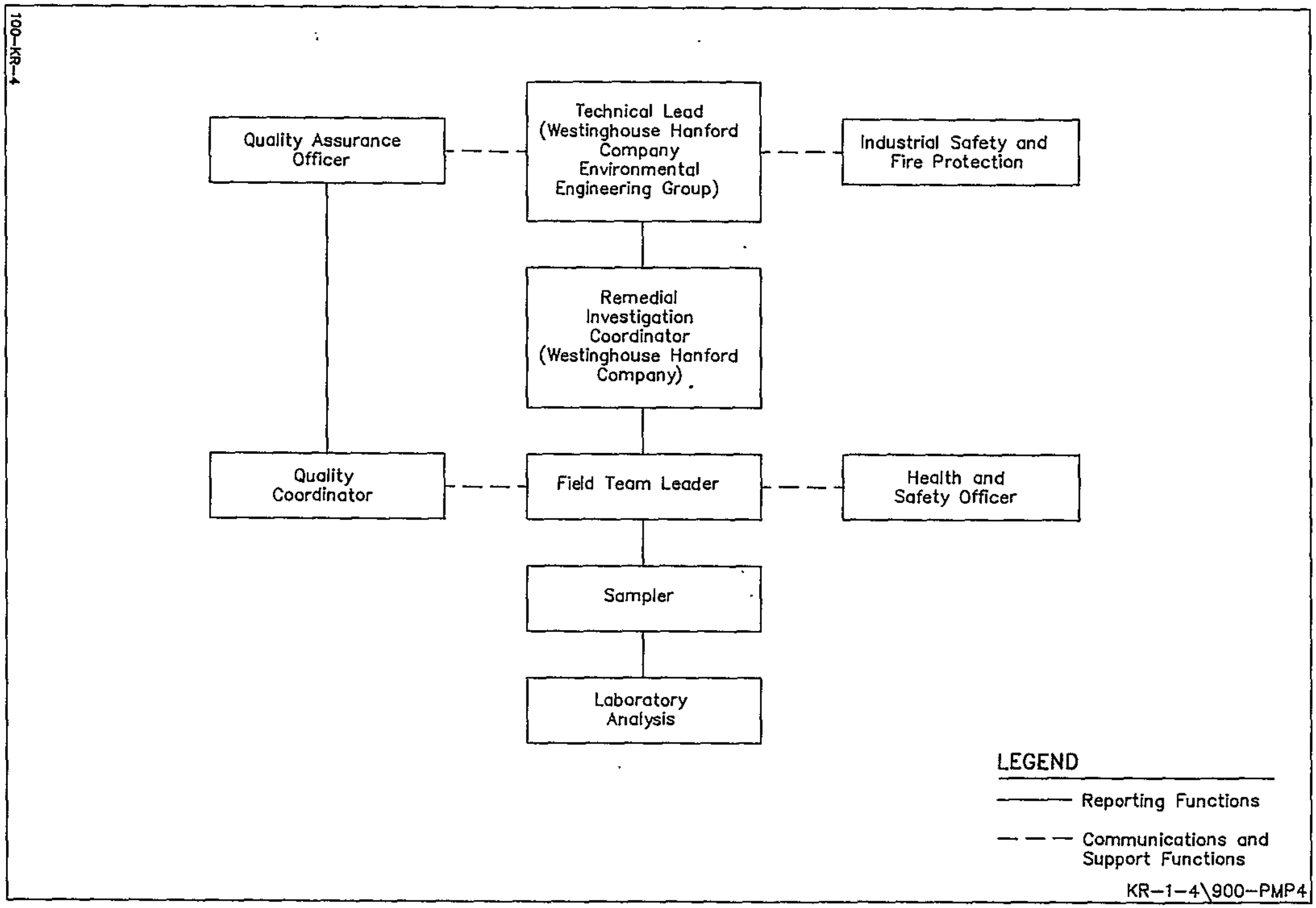

Figure PMP-4. The Hanford Site Soil Sampling Team.

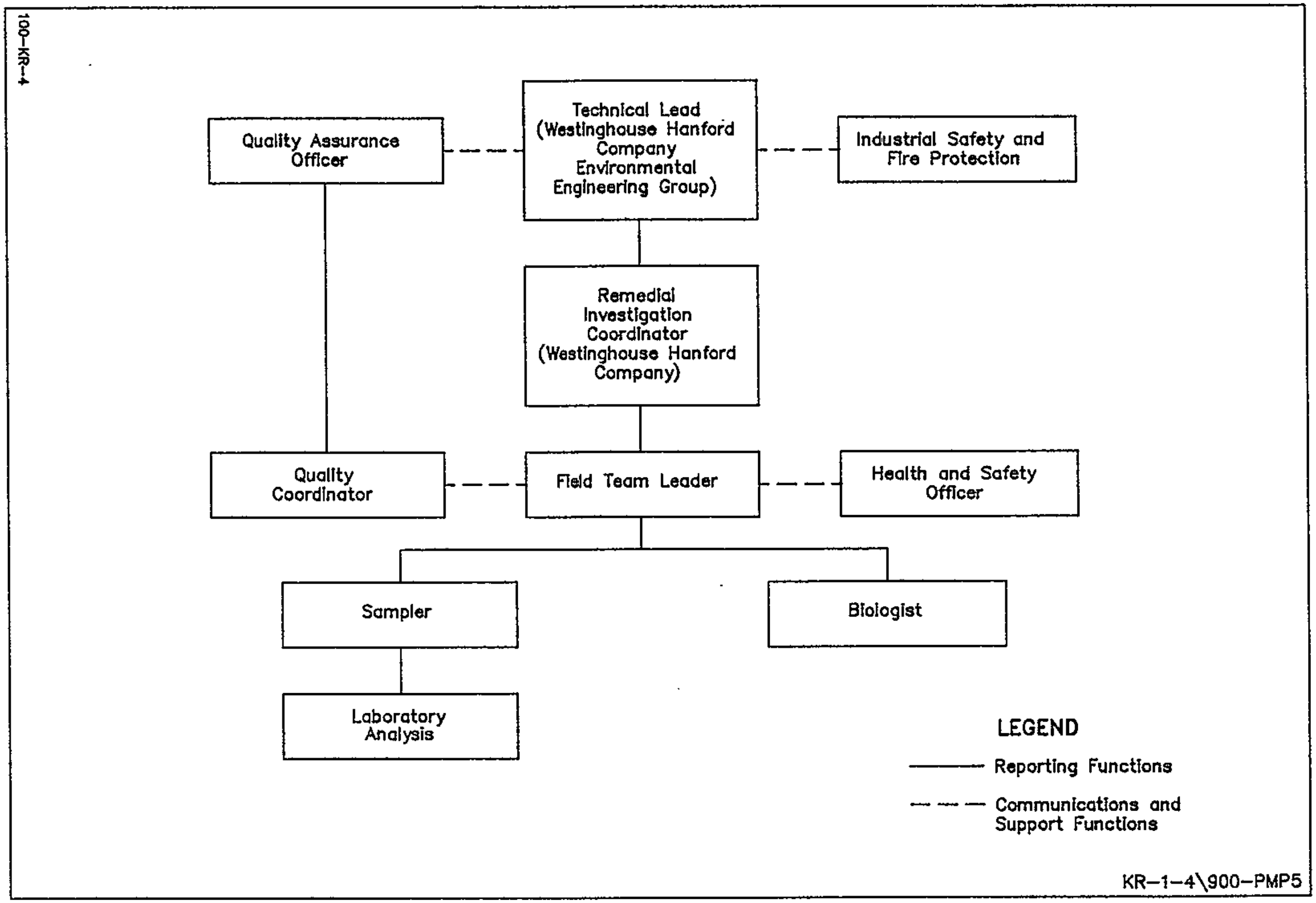

Figure PMP-5. The Hanford Site Biological Sampling Team.

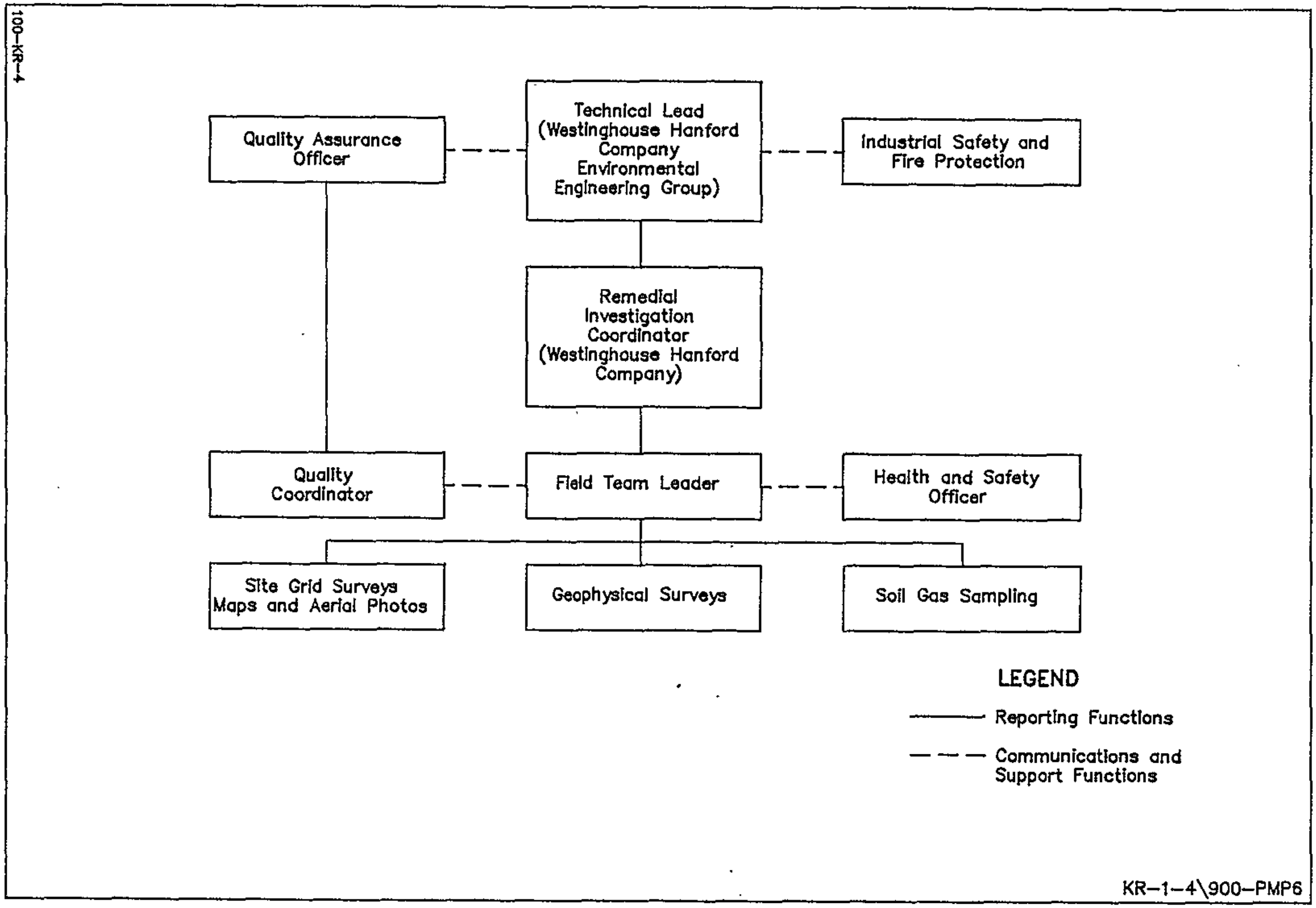

Figure PMP-6. The Hanford Site Physical and Geophysical Survey Team.

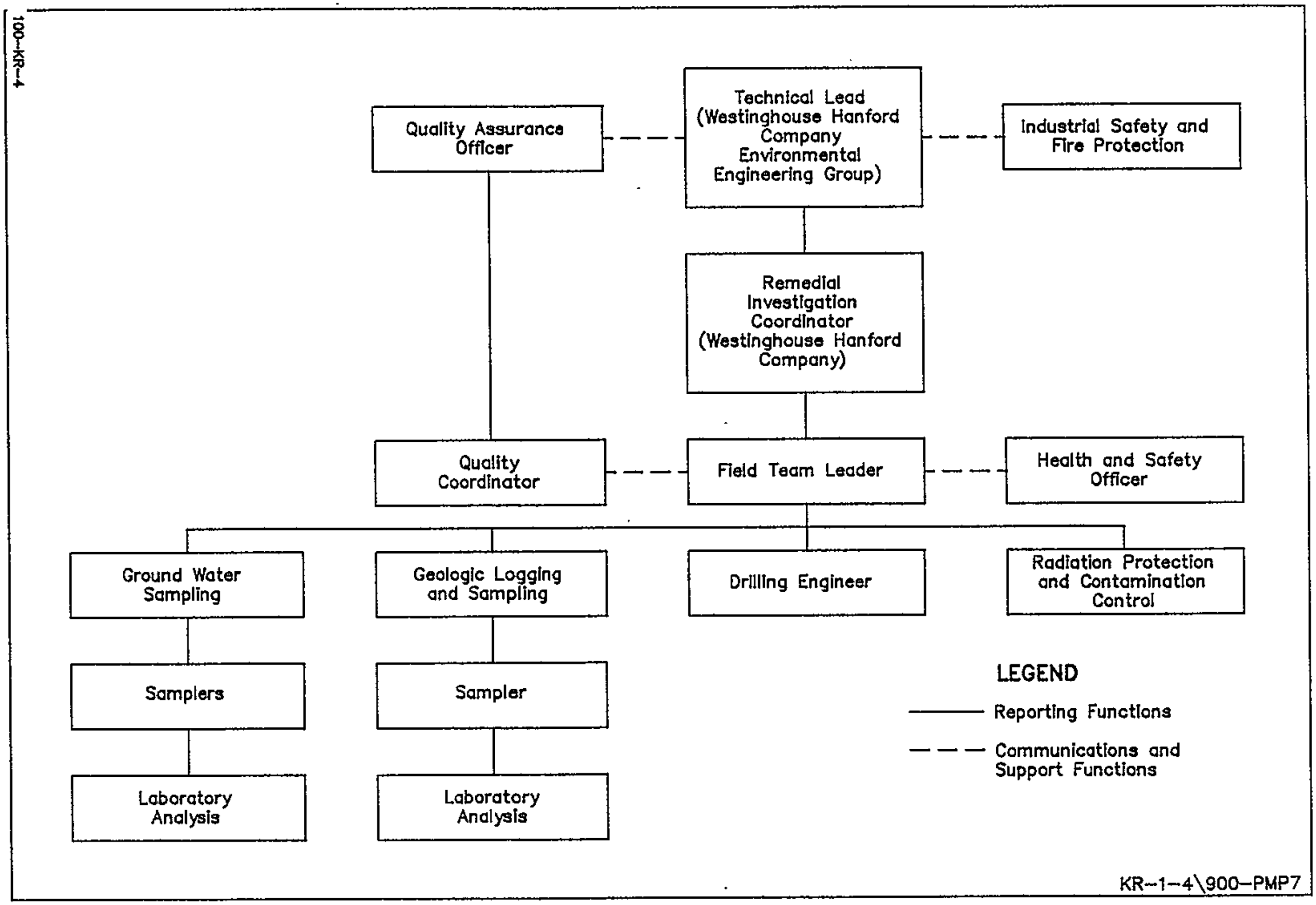

Figure PMP-7. The Hanford Site Drilling and Sampling Team.

4.0 FINANCIAL AND PROJECT TRACKING REQUIREMENTS

4.1 MANAGEMENT CONTROL

Westinghouse Hanford will have the overall responsibility for planning and controlling the RI/FS activities, and providing effective technical, cost, and schedule baseline management. If an offsite RI/FS contractor is used, the contractor will assume the direct day-to-day responsibilities for these management functions. The management control system used for this project must meet the requirements of DOE Order 4700.1, *Project Management System* (DOE 1987), and DOE Order 2250.1B, Cost and Schedule Control Systems Criteria for Contract Performance Measurement (DOE 1985). The Westinghouse Hanford Management Control System (MCS) meets these requirements. The primary goals of the Westinghouse Hanford MCS are to provide methods for planning, authorizing, and controlling work so that it can be completed on schedule and within budget, and to ensure that all planning and work performance activities are technically sound and in conformance with management and quality requirements.

The RI/FS schedule for the 100-KR-4 operable unit and major milestones are described in Chapter 6.0 of the work plan. The schedule in the work plan will be the primary vehicle for the unit lead and technical lead to track the progress of the RI/FS for the 100-KR-4 operable unit. The RI/FS schedule must be consistent with the work schedule contained in the action plan.

The RI/FS schedule in the 100-KR-4 operable unit work plan will be updated at least annually, to expand the new current fiscal year and the follow-on year. In addition, any approved schedule changes would be incorporated at this time, if not previously incorporated. This update will be performed in the fourth quarter of the previous fiscal year for the upcoming current fiscal year. The work schedule can be revised at any time during the year if the need arises, but the changes would be restricted to major changes that would not be suitable for the change control process.

4.2 MEETINGS AND PROGRESS REPORTS

Both project and unit managers must meet periodically to discuss progress, review plans, and address any issues that have arisen. The project managers' meeting will take place at least quarterly and is discussed in Section 8 of the action plan.

Unit managers shall meet monthly to discuss progress, address issues, and review near-term plans pertaining to their respective operable units and/or treatment, storage, and disposal groups/units. The meetings shall be technical in nature, with emphasis on technical issues and work progress. The assigned DOE unit manager for the 100-KR-4 operable unit will be responsible for preparing revisions to the RI/FS schedule prior to the meeting. The schedule shall address all ongoing activities associated with the operable unit, including actions on specific source units (e.g., sampling). This schedule will be provided to all parties and reviewed at the meeting. Any agreements and commitments (within the unit manager's level of authority) resulting from the meeting will be prepared and signed by all parties as soon as possible after the meeting. Meeting minutes will be issued by the DOE unit manager and will summarize the discussion at the meeting, with information copies given to the project managers. The minutes will be issued within 5-working days following the meeting. The minutes will include, at a minimum, the following:

- Status of previous agreements and commitments
- Any new agreements and commitments
- Schedules (with current status noted)
- Any approved changes signed off at the meeting in accordance with the appropriate Section in the action plan.

Project coordinators for each operable unit also will meet on a monthly basis to share information and to discuss progress and problems.

The DOE shall issue a quarterly progress report for the Hanford Site within 45 days following the end of each quarter. Quarters end on March 30, June 30, September 30, and December 31. The quarterly progress reports will be placed in the public information repositories and include the following:

- Highlights of significant progress and problems
- Technical progress with supporting information, as appropriate
- Problem areas with recommended solutions. This will include any anticipated delays in meeting schedules, the reason(s) for the potential delay, and actions to prevent or minimize the delay
- Significant activities planned for the next quarter
- Work schedules (with current status noted).

5.0 REFERENCES

DOE, 1985, *Cost and Schedule Control Systems Criteria for Contract Performance Measurement*, DOE Order 2250.1B, U.S. Department of Energy, Washington, D.C.

DOE, 1987, *Project Management System*, DOE Order 4700.1, U.S. Department of Energy, Washington, D.C.

Ecology et al. 1989, *Hanford Federal Facility Agreement and Consent Order*, State of Washington Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington.

Attachment 4

DATA MANAGEMENT PLAN

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CONTENTS

CONTENTS (cont)

FIGURES

TABLES

1.0 INTRODUCTION AND OBJECTIVES

An extensive amount of data will be generated in connection with the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) remedial investigation/feasibility study (RI/FS) process for the 100-KR-4 operable unit. The quality of these data is extremely important to the full remediation of the operable unit as agreed upon by the U.S. Department of Energy (DOE), U.S. Environmental Protection Agency (EPA), State of Washington Department of Ecology (Ecology), and interested parties.

1.1 INTRODUCTION

This data management plan (DMP) addresses management of data generated as a result of the 100-KR-4 operable unit work plan, field sampling plan (FSP), quality assurance project plan (QAPP), and health and safety plan (HSP) activities.

Development of a comprehensive plan for the management of all environmental data generated at the Hanford Site is under way. The *Environmental Information Management Plan* (EIMP) (Steward 1989), released in March 1989, describes activities in the Environmental Data Management Center (EDMC) and provides a description of the long-range goals for management of scientific and technical data. The EIMP is currently under review and is expected to be revised and expanded in fiscal year 1990.

1.2 OBJECTIVES

This DMP describes the process for the data collection and control procedures for validated data, records, documents, correspondence, and other information associated with the 100-KR-4 RI/FS.

This DMP addresses the following:

- Types of data to be collected
- Plans for managing data
- Organizations controlling data
- Databases used to store the data
- Environmental Information Management Plan
- Hanford Environmental Information System (HEIS).

2.0 TYPES OF DATA

2.1 DATA TYPES

General data types include field logbooks, verified sample analyses, historic data, chain-of-custody forms, quality assurance/quality control (QA/QC) data, reports, memoranda/meeting minutes, telephone conversations, archived samples, raw sample data, videotapes, magnetic media and supporting documentation, paper tapes, personnel training records, exposure records, respiratory protection fitting records, personnel health and safety records, and compliance and regulatory data. Table DMP-1 lists the data types and applicable procedures by work plan task. Table DMP-2 lists data types for health and safety planning, as well as for regulatory compliance activities.

2.2 DATA COLLECTION

Data will be collected according to the FSP and the QAPP. Table DMP-1 lists controlling procedures for data collection and handling before turnover of responsibility to the organization responsible for data storage. All procedures for data collection will be approved in compliance with applicable Westinghouse Hanford Company (Westinghouse Hanford) procedures. Where Westinghouse Hanford environmental investigations instructions (EII) are referenced, they will be the latest approved versions from the *Environmental Investigations and Site Characterizations Manual* (WHC 1989).

2.3 DATA STORAGE AND ACCESS

Data will be handled and stored according to procedures approved in compliance with applicable Westinghouse Hanford procedures. Data-controlling organizations are listed in Table DMP-1 and Table DMP-2. The EDMC is the central files manager and process facility. All data entering the EDMC will be indexed, recorded, and placed into safe and secure storage. Data designated for placement into the administrative record will be copied, placed into the Hanford Site Administrative Record File, and distributed by the EDMC to the user community.

The following data types will reside in locations other than the EDMC.

Data type		Data location
QA/QC laboratory data	-	Office of Sample Management (OSM) (Westinghouse Hanford)
Archived sample index	-	OSM (Westinghouse Hanford)
Archived samples	-	Laboratory performing analyses (see the archived sample index)

Table DMP-1. Site Characterization. (sheet 1 of 13)

Work plan task	Data type	Procedure	Database or controlling organization EDMC[a]	Others
Operable unit characterization				
Task 1 - Project management (addressed in project management plan)				
Task 2 - Source investigations				
Subtask 2a-data compilations	Historic	EII 1.6	X	
	Engineering plans, reports			
	Telephone conversations	EII 1.6	X	
	Memoranda/minutes	EII 1.6	X	
Subtask 2b-field activities	Log books	EII 1.5	X	
	Magnetic media and supporting documentation	EII 1.6	X	
	Chart recordings	EII 1.6	X	
	Chain of custody	EII 5.1	X	
	QA/QC		X	OSM[b]

Table DMP-1. Site Characterization. (sheet 2 of 13)

Work task plan	Data type	Procedure	Database or controlling organization EDMC[a]	Others
Task 3 - Geological investigations				
Subtask 3a-data compilation	Technical memos	EII 1.6	X	
	Geological logs	EII 9.1	X	
Subtask 3b-field activities	Aerial photographs	EII 1.6	X	
	Log books	EII 1.5 EII 11.1	X X	
	Magnetic media and supporting documentation	EII 1.6	X	
	Chart recordings	EII 1.6	X	
	Core/cutting samples	EII 5.2	X	
	Chain of custody	EII 1.5	X	
	QA/QC			OSM
	Geophysical surveys	EII 11.2	X	
Subtask 3c-laboratory analysis	Validated sample analysis	EII 1.6	X	
	QA/QC	EII 1.6	X	OSM

Table DMP-1. Site Characterization. (sheet 3 of 13)

Work task plan	Data type	Procedure	Database or controlling organization EDMC[a]	Database or controlling organization Others
Subtask 3d-data evaluation	Log books	EII 1.5	X	
	QA/QC	EII 1.6	X	
Task 4 - Surface water and sediments investigations				
Subtask 4a-data compilation	Technical memos	EII 1.6	X	
Subtask 4b-field activities	Aerial photographs	EII 1.6	X	
	Log books	EII 1.5 EII 11.1	X X	
	Magnetic media and supporting documentation	EII 1.6	X	
	Chart recordings	EII 1.6	X	
	Chain of custody	EII 1.5	X	
	QA/QC			OSM
Subtask 4c-laboratory analysis	Validated sample analysis	EII 1.6	X	
	QA/QC	EII 1.6	X	OSM
Subtask 4d-data evaluation	Log books	EII 1.5	X	
	QA/QC	EII 1.6	X	

Table DMP-1. Site Characterization. (sheet 4 of 13)

Work task plan	Data type	Procedure	Database or controlling organization EDMC[a]	Others
Task 5 - Vadose investigations (see data management plan)				
Subtask 5a-data compilation	Technical memos	EII 1.6	X	
	Geological logs	EII 9.1	X	
	Archived sample index			OSM
Subtask 5b-field activities	Aerial photographs	EII 1.6	X	
	Log books	EII 1.5 EII 11.1	X X	
	Magnetic media and supporting documentation	EII 1.6	X	
	Chart recordings	EII 1.6	X	
	Core/cutting samples	EII 5.2	X	
	Chain of custody	EII 1.5	X	
	QA/QC			OSM
	Geophysical surveys	EII 11.2	X	
	Aquifer tests	EII 9.1	X	
	Water levels	EII 10.2	X	
	Calibration records	EII 3.3	X	

Table DMP-1. Site Characterization. (sheet 5 of 13)

Work plan task	Data type	Procedure	Database or controlling organization EDMC[a]	Others
Subtask 5c-laboratory analysis	Validated sample analysis	EII 1.6	X	
	QA/QC	EII 1.6	X	OSM
Subtask 5d-data evaluation	Log books	EII 1.5	X	
	QA/QC	EII 1.6	X	
Task 6 - Ground water investigations				
Subtask 6a-data compilation	Technical memos	EII 1.6	X	
	Geological logs	EII 9.1	X	
	Archived sample index			OSM
Subtask 6b-field activities	Aerial photographs	EII 1.6	X	
	Log books	EII 1.5 EII 11.1	X X	
	Magnetic media and supporting documentation	EII 1.6	X	
	Chart recordings	EII 1.6	X	
	Core/cutting samples	EII 5.2	X	
	Chain of custody	EII 1.5	X	
	QA/QC			OSM

Table DMP-1. Site Characterization. (sheet 6 of 13)

Work plan task	Data type	Procedure	Database or controlling organization EDMC[a]	Others
Subtask 6b-field activities continued	Geophysical surveys	EII 11.2	X	
	Aquifer tests	EII 9.1	X	
	Water levels	EII 10.2	X	
	Calibration records	EII 3.3	X	
Subtask 6c-laboratory analysis	Validated sample analysis	EII 1.6	X	
	QA/QC	EII 1.6	X	
Subtask 6d-data evaluation	Log books	EII 1.5	X	
	QA/QC	EII 1.6	X	
Task 7 - Air investigations (see data management plan)				
Task 8 - Ecological investigations				
Subtask 8a-data compilation	Technical memos	EII 1.6	X	
Subtask 8b-field activities	Aerial photographs	EII 1.6	X	
	Log books	EII 1.5 EII 11.1	X X	
	Magnetic media and supporting documentation	EII 1.6	X	

Table DMP-1. Site Characterization. (sheet 7 of 13)

Work plan task	Data type	Procedure	Database or controlling organization EDMC[a]	Others
Subtask 8b-field activities (continued)	Chart recordings	EII 1.6	X	
	Chain of custody	EII 1.5	X	
	QA/QC		X	OSM
Subtask 8c-laboratory analysis	Validated sample analysis	EII 1.6	X	
	QA/QC	EII 1.6	X	OSM
Subtask 8d-data evaluation	Log books	EII 1.5	X	
	QA/QC	EII 1.6	X	
Task 9 - Other investigations				
Subtask 9a-cultural resource investigations	Hanford plan	PNL-6942		
Subtask 9b-Topographic base map development	Aerial photographs	EII 1.6	X	
	Log books	EII 1.5	X	
	Magnetic media and supporting documentation	EII 1.6	X	
	Maps	EII 1.6	X	

Table DMP-1. Site Characterization. (sheet 8 of 13)

Work plan task	Data type	Procedure	Database or controlling organization EDMC[a]	Others
Task 10 - Data evaluations	Technical memos	EII 1.6	X	
Task 11 - Baseline risk assessment	Technical memos	EII 1.6	X	
	Computer models	EII 1.6	X	
	Magnetic media and supporting documentation	EII 1.6	X	
Task 12 - Report				
Subtask 12a-prepare	Report	EII 1.6	X	
Subtask 12b-review/approval	Approval	EII 1.6	X	
FS PHASE I/II REMEDIAL ALTERNATIVES DEVELOPMENT				
Task 1 - Project management (addressed in project management plan)				
Task 2 - Alternatives development				
Subtask 2a-Develop objectives	Technical memos	EII 1.6	X	
Subtask 2b-develop general response actions	Technical memos	EII 1.6	X	
Subtask 2c-identify potential technologies	Technical memos	EII 1.6	X	
Subtask 2d-evaluate process options	Technical memos	EII 1.6	X	

Table DMP-1. Site Characterization. (sheet 9 of 13)

Work plan task	Data type	Procedure	Database or controlling organization EDMC[a]	Others
Subtask 2e-assemble alternatives	Technical memos	EII 1.6	X	
Subtask 2f-identify/action-specific ARARs	Technical memos	EII 1.6	X	
Task 3 - Alternatives screening				
Subtask 3a-refine objectives	Technical memos	EII 1.6	X	
Subtask 3b-define alternatives	Technical memos	EII 1.6	X	
Subtask 3c-screen alternatives	Technical memos	EII 1.6	X	
Subtask 3d-identify/action-specific ARARs	Technical memos	EII 1.6	X	
Subtask 3e-evaluate data needs	Technical memos	EII 1.6	X	
Task 4 - Report				
Subtask 4a-prepare	Report	EII 1.6	X	
Subtask 4b-review/approval	Approval	EII 1.6	X	

Table DMP-1. Site Characterization. (sheet 10 of 13)

Work plan task	Data type	Procedure	Database or controlling organization EDMC[a]	Others
RI PHASE II OPERABLE UNIT CHARACTERIZATION AND TREATABILITY				
Task 1 - Project management (addressed in project management plan)				
Task 2 - Source investigations				
Subtask 2a-data compilation and review	Technical memos	EII 1.6	X	
Subtask 2b-field activities	Technical memos	EII 1.6	X	
Subtask 2c-other	TBD			
Task 3 - Geologic investigations				
Subtask 3a-field activities	Technical memos	EII 1.6	X	
Subtask 3b-laboratory analysis	Technical memos	EII 1.6	X	
Subtask 3c-data evaluation	Technical memos	EII 1.6	X	
Task 4 - Surface water and sediments investigations				
Subtask 4a-field activities	Technical memos	EII 1.6	X	
Subtask 4b-laboratory analysis	Technical memos	EII 1.6	X	

Table DMP-1. Site Characterization. (sheet 11 of 13)

Work plan task	Data type	Procedure	Database or controlling organization EDMC[a]	Others
Subtask 4c-data evaluation	Technical memos	EII 1.6	X	
Task 5 - Vadose zone investigations				
Subtask 5a-field activities	Technical memos	EII 1.6	X	
Subtask 5b-laboratory analysis	Technical memos	EII 1.6	X	
Subtask 5c-data evaluation	Technical memos	EII 1.6	X	
Task 6 - Ground water investigations				
Subtask 6a-field activities	Technical memos	EII 1.6	X	
Subtask 6b-laboratory analysis	Technical memos	EII 1.6	X	
Subtask 6c-data evaluation	Technical memos	EII 1.6	X	
Task 7 - Air investigations				
Subtask 7a-field activities	Technical memos	EII 1.6	X	
Subtask 7b-laboratory analysis	Technical memos	EII 1.6	X	
Subtask 7c-data evaluation	Technical memos	EII 1.6	X	
Task 8 - Ecological investigations				
Subtask 8a-field activities	Technical memos	EII 1.6	X	
Subtask 8b-laboratory analysis	Technical memos	EII 1.6	X	

Table DMP-1. Site characterization. (sheet 12 of 13)

Work plan task	Data type	Procedure	Database or controlling organization	
			EDMC[a]	Other
Subtask 8c-data evaluation	Technical memos	EII 1.6	X	
Task 9 - Treatability work plan development	Work Plan	EII 1.6	X	
Task 10 - Treatability work plan implementation	Pilot and test data/ log books	EII 1.5	X	
	Sample analysis	EII 1.6	X	
	Magnetic media	EII 1.6	X	
	Technical memos	EII 1.6	X	
Task 11 - Cultural resource investigations	Plan	PNL-6942		
Task 12 - Data evaluation	Log books	EII 1.5	X	
	QA/QC	EII 1.6	X	
Task 13 - Baseline risk assessment	Technical memos	EII 1.6	X	
Task 14 - Report				
Subtask 14a-prepare	Report	EII 1.6	X	
Subtask 14b-review/approve	Report	EII 1.6	X	
FS PHASE III REMEDIAL ALTERNATIVES ANALYSIS				
Task 1 - Define alternatives	Technical memos	EII 1.6	X	

Table DMP-1. Site Characterization. (sheet 13 of 13)

Work plan task	Data type	Procedure	Database or controlling organization EDMC[a]	Others
Task 2 - Alternative analysis	Technical memos	EII 1.6	X	
Task 3 - Compare alternatives	Technical memos	EII 1.6	x	
Task 4 - Report				
Subtask 4a-prepare	Report	EII 1.6	X	
Subtask 4b-review/approve	Report	EII 1.6	X	
Task 5 - Corrective action plan	Plan	EII 1.6	X	
NEPA				
Task 1 - Analyze	Technical memos	EII 1.6	X	
Task 2 - Prepare	Report	EII 1.6	X	
Task 3 - Review/approve	Report	EII 1.6	X	
CLOSURE PERMITS				
Task 1 - Prepare	Report	EII 1.6	X	
Task 2 - Review/approve	Report	EII 1.6	X	
INTERIM REMEDIAL ACTIONS	Technical memos to be determined	EII 1.6	X	

[a]EDMC = Environmental Data Management Center.
[b]OSM = Office of Sample Management.

Table DMP-2. Management of Related Administrative Data. (sheet 1 of 2)

Category	Data type	Controlling document/procedure	Database or controlling organization TRI	HEHF	ORE	EDMC	EHPSS
Personnel	Personnel training and qualifications	See Section 3.0					
	Occupational exposure records(nonradiological)	EII 2.2		X			X
	Radiological exposure records	See Section 3.0				X	
	Respiratory protection fitting						X
	Personal health and safety records	EII 2.1		X			X
Regulatory compliance	Applicable or relevant and appropriate requirements/ screening levels	EII 1.6				X	
	Guidance document tracking	EII 1.6				X	

Table DMP-2. Management of Related Administrative Data. (sheet 2 of 2)

Category	Data type	Controlling document/procedure	Database or controlling organization TRI	HEHF	ORE	EDMC	EHPSS
Regulatory compliance	Compliance issues	EII 1.6				X	
	Problem resolution	EII 1.6				X	
	Administrative record	TPA-AP-06-R0 TPA-AP-10-R0				X	

TRI = Training Record Information System
HEHF = Hanford Environmental Health Foundation
ORE = Occupation Radiation Exposure
EDMC = Environmental Data Management Center
EHPSS = Environmental Health and Pesticide Services Section.

Data type		Data location
Training records	-	Technical training support section (Westinghouse Hanford)
Meteorological data	-	Hanford Meteorological Station (Pacific Northwest Laboratory)
Health and safety	-	Hanford Environmental Health Foundation (HEHF) records
Personal protection fitting	-	Environmental Health and Pesticide Services Section (Westinghouse Hanford)
Radiological exposure	-	Pacific Northwest Laboratory.

2.4 DATA QUANTITY

Data quantities are described in the 100-KR-1 operable unit work plan and the FSP. Estimated data quantities, as shown in Table DMP-3, are provided for the purpose of data volume and work load planning.

3.0 DATA MANAGEMENT

The following sections disucuss data management objectives, organizations controlling the data and databases.

3.1 OBJECTIVE

A considerable amount of data will be generated through the implementation of the 100-KR-4 operable unit work plan, FSP, and HSP. The QAPP provides the specific procedural direction and control for obtaining and analyzing samples in conformance with requirements to ensure quality data results. The FSP provides the detailed logistical methods to be employed in selecting the location, depth, frequency of collection, etc., of media to be sampled and the methods to be employed to obtain samples of the selected media for cataloging, shipment, and analysis.

Figure DMP-1 displays the general DMP outline for data generated through 100-KR-4 operable unit activities.

3.2 ORGANIZATIONS CONTROLLING DATA

This section describes the organizations that will receive data generated from 100-KR-4 operable unit activities.

Table DMP-3. Site Characterization - Estimated Data Quantity. (sheet 1 of 17)

Work plan task	Data type	Estimated number of documents/ articles	Estimated number of sample locations	Estimated total number of samples	Estimated number of analyses/ per sample	Estimated total number of data points
OPERABLE UNIT CHARACTERIZATION						
Task 1 - Project management (addressed in project management plan)						
Task 2 - Source investigations						
Subtask 2a-data compilation	Historic:	25				
	Engineering plans, reports					
	Personal interviews	10				
	Memoranda and minutes	10				
Subtask 2b-maps	Aerial photographs	10				
	Log books	1				
	Magnetic Media and Supporting Documentation	1				

Table DMP-3. Site Characterization - Estimated Data Quantity. (sheet 2 of 17)

Work plan task	Data type	Estimated number of documents/ articles	Estimated number of sample locations	Estimated total number of samples	Estimated number of analyses/ per sample	Estimated total number of data points
Subtask 2b-maps continued	Maps	5				
Subtask 2c-field activities	Log books	4				
	Magnetic media and supporting documentation	4				
	Chart recordings					
	Chain of custody	14	60	185	7	
	QA/QC	10	14	185		
Subtask 2d-laboratory analysis	Validated sample analysis	1		183	7	1,295
	QA/QC	1		183	7	1,295
Subtask 2e-data evaluation	Log books	1				

Table DMP-3. Site Characterization - Estimated Data Quantity. (sheet 3 of 17)

Work plan task	Data type	Estimated number of documents/ articles	Estimated total number of sample locations	Estimated total number of samples	Estimated number of analyses/ per sample	Estimated total number of data points
Subtask 2e-data evaluation continued	QA/QC	1				
Task 3 - Geological investigations						
Subtask 3a-data compilation	Reports and documents	10				
	Geological logs	30				
Subtask 3b-field activities	Aerial photographs	4				
	Log books	4				
	Magnetic media and supporting documentation	4				
	Chart recordings					
	Core/cutting samples					

Table DMP-3. Site Characterization - Estimatred Data Quantity. (sheet 4 of 17)

Work plan task	Data type	Estimated number of documents/ articles	Estimated total number of sample locations	Estimated total number of samples	Estimated number of analyses/ per sample	Estimated total number of data points
Subtask 3b-field activities continued	Chain of custody	10	31	185	6	
	QA/QC	10		45		
Subtask 3c-laboratory analysis	Validated sample analysis	1		45	6	270
Subtask 3d-data evaluation	QA/QC	1		45	6	270
	Log books	1				
	QA/QC	1				
Task 4 - Surface water and sediments investigations (see data management plan)						
Task 5 - Vadose investigations						
Subtask 5a-data compilation	Technical memos	10				
	Geological logs	10				
Subtask 5b-field activities	Aerial photographs	4				
	Log books	4				

Table DMP-3. Site Characterization - Estimated Data Quantity. (sheet 5 of 17)

Work plan task	Data type	Estimated number of documents/ articles	Estimated number of sample locations	Estimated total number of samples	Estimated number of analyses/ per sample	Estimated total number of data points
Subtask 5b-field activities continued	Magnetic media and supporting documentation	4				
	Chart recordings	17				
	Core/cutting samples		17	310		
	QA/QC	10	17	310		
	Geophysical surveys	17	17			
	Borehole logs	17				
Subtask 5c-laboratory analysis	Validated sample analysis	1		310	7	
	QA/QC	1		310	7	
Subtask 5d-data evaluation	Log books	1				2,170
	QA/QC	1				2,170

Table DMP-3. Site Characterization - Estimated Data Quantity. (sheet 6 of 17)

Work plan task	Data type	Estimated number of documents/ articles	Estimated number of sample locations	Estimated total number of samples	Estimated number of analyses/ per sample	Estimated total number of data points
Task 6 - Ground water investigations (see data management plan for 100-KR-4 operable unit)						
Task 7 - Air investigations						
Subtask 7a-data compilation	Technical memos	1				
	Historic reports	5				
Subtask 7b-field activities	Aerial photographs	1				
	Log books	1				
	Magnetic media and supporting documentation	1				
	QA/QC	1				
Subtask 7c-laboratory analysis	Validated sample analysis	31				
	QA/QC	31				

Table DMP-3. Site Characterization - Estimated Data Quantity. (sheet 7 of 17)

Work plan task	Data type	Estimated number of documents/ articles	Estimated number of sample locations	Estimated total number of samples	Estimated number of analyses/ per sample	Estimated total number of data points
Subtask 7d-data evaluation	Log books	1				
	QA/QC	1				
Task 8 - Ecological investigations						
Subtask 8a-data compilation	Technical memos	1				
Subtask 8b-field activities	Aerial photographs	10				
	Log books	1				
	Magnetic media and supporting documentation	1				
	Chart recordings					
	Chain of custody	5				
	QA/QC	5	TBD	TBD	TBD	TBD

Table DMP-3. Site Characterization - Estimated Data Quantity. (sheet 8 of 17)

Work plan task	Data type	Estimated number of documents/ articles	Estimated number of sample locations	Estimated total number of samples	Estimated number of analyses/ per sample	Estimated total number of data points
Subtask 8c-laboratory analysis	Validated sample analysis					
	QA/QC					
Subtask 8d-data evaluation	Log books	1				
	QA/QC	1				
Task 9 - Cultural resource investigations	Hanford plan	1				
Task 10 - Data evaluations	Technical memos	1				
Task 11 - Baseline risk assessment	Technical memos	1				
	Computer models	4				
	Magnetic media and supporting documentation	4				

Table DMP-3. Site Characterization - Estimated Data Quantity. (sheet 9 of 17)

Work plan task	Data type	Estimated number of documents/ articles	Estimated number of sample locations	Estimated total number of samples	Estimated number of analyses/ per sample	Estimated total number of data points
Task 12 - Report						
Subtask 12a-prepare	Report	1				
Subtask 12b-review/approval	Approval	1				
FS PHASE I/II REMEDIAL ALTERNATIVES DEVELOPMENT						
Task 1 - Project management (addressed in project management plan)						
Task 2 - Alternatives development						
Subtask 2a-Develop objectives	Technical memos	1				
Subtask 2b-Develop general response actions	Technical memos	1				
Subtask 2c-identify potential technologies	Technical memos	1				

Table DMP-3. Site Characterization - Estimated Data Quantity. (sheet 10 of 17)

Work plan task	Data type	Estimated number of documents/ articles	Estimated number of sample locations	Estimated total number of samples	Estimated number of analyses/ per sample	Estimated total number of data points
Subtask 2d-evaluate process options	Technical memos	3				
Subtask 2e-assemble alternatives	Technical memos	1				
Subtask 2f-identify/action-specific ARARs	Technical memos	1				
Task 3 - Alternatives screening						
Subtask 3a-refine objectives	Technical memos	1				
Subtask 3b-define alternatives	Technical memos	1				
Subtask 3c-screen alternatives	Technical memos	1				
Subtask 3d-identify/action-specific ARARs	Technical memos	1				

Table DMP-3. Site Characterization - Estimated Data Quantity. (sheet 11 of 17)

Work plan task	Data type	Estimated number of documents/ articles	Estimated number of sample locations	Estimated total number of samples	Estimated number of analyses/ per sample	Estimated total number of data points
Subtask 3e-evaluate data needs	Technical memos	1				
Task 4 - Report						
Subtask 4a-prepare	Report	1				
Subtask 4b-review/approval	Approval	1				
RI PHASE II OPERABLE UNIT CHARACTERIZATION AND TREATABILITY						
Task 1 - Project management (addressed in project management plan)						
Task 2 - Source investigations						
Subtask 2a- data compilation and review	Technical memos	1				
Subtask 2b-field activities	Technical memos	1				
Subtask 2c-other	To be determined	TBD				

Table DMP-3. Site Characterization - Estimated Data Quantity. (sheet 12 of 17)

Work plan task	Data type	Estimated number of documents/ articles	Estimated number of sample locations	Estimated total number of samples	Estimated number of analyses/ per sample	Estimated total number of data points
Task 3 - Geologic investigations						
Subtask 3a-field activities	Technical memos	1				
Subtask 3b-laboratory analysis	Technical memos	1				
Subtask 3c-data evaluation	Technical memos	1				
Task 4 - Surface water and sediments investigations						
Subtask 4a-field activities	Technical memos	1				
Subtask 4b-laboratory analysis	Technical memos	1				
Subtask 4c-data evaluation	Technical memos	1				
Task 5 - Vadose zone investigations						

Table DMP-3. Site Characterization - Estimated Data Quantity. (sheet 13 of 17)

Work plan task	Data type	Estimated number of documents/ articles	Estimated number of sample locations	Estimated total number of samples	Estimated number of analyses/ per sample	Estimated total number of data points
Subtask 5a-field activities	Technical memos	1				
Subtask 5b-laboratory analysis	Technical memos	1				
Subtask 5c-data evaluation	Technical memos	1				
Task 6 - Ground water investigations						
Subtask 6a-field activities	Technical memos	1				
Subtask 6b-laboratory analysis	Technical memos	1				
Subtask 6c-data evaluation	Technical memos	1				
Task 7 - Air investigations						
Subtask 7a-field activities	Technical memos	1				

Table DMP-3. Site Characterization - Estimated Data Quantity. (sheet 14 of 17)

Work plan task	Data type	Estimated number of documents/ articles	Estimated number of sample locations	Estimated total number of samples	Estimated number of analyses/ per sample	Estimated total number of data points
Subtask 7b-laboratory analysis	Technical memos	1				
Subtask 7c-data evaluation	Technical memos	1				
Task 8 - Ecological investigations						
Subtask 8a-field activities	Technical memos	1				
Subtask 8b-laboratory analysis	Technical memos	1				
Subtask 8c-data evaluation	Technical memos	1				
Task 9 - Treatability work plan development	Work-plan	Unknown				
Task 10 - Treatability work plan implementation	Pilot and test data/log books Sample analysis Magnetic media Technical memos	Unknown				

Table DMP-3. Site Characterization - Estimated Data Quantity. (sheet 15 of 17)

Work plan task	Data type	Estimated number of documents/ articles	Estimated number of sample locations	Estimated total number of samples	Estimated number of analysis/ per sample	Estimated total number of data points
Task 11-Cultural resource investigations	Plan	1				
Task 12 - Data evaluation	Log books QA/QC	1				
Task 13 - Baseline risk assessment	Technical memos	1				
Task 14 - Report						
Subtask 14a-prepare	Report	1				
Subtask 14b-review/approve	Report	1				
FS PHASE III REMEDIAL ALTERNATIVE ANALYSIS						
Task 1 - Define alternatives	Technical memos	1				
Task 2 - Alternative analysis	Technical memos	1				

Table DMP-3. Site Characteristics - Estimated Data Quantity. (sheet 16 of 17)

Work plan task	Data type	Estimated number of documents/ articles	Estimated number of sample locations	Estimated total number of samples	Estimated number of analyses/ per sample	Estimated total number of data points
Task 3 - Compare alternatives	Technical memos	1				
Task 4 - Report						
Subtask 4a-prepare	Report	1				
Subtask 4b-review/approve	Report	1				
Task 5 - Corrective Action Plan	Plan	1				
NEPA						
Task 1 - Analyze	Technical memos	1				
Task 2 - Prepare	Report	1				
Task 3 - Review/approve	Report	1				
CLOSURE PERMITS						

Table DMP-3. Site Characterization - Estimated Data Quantity. (sheet 17 of 17)

Work plan task	Data type	Estimated number of documents/ articles	Estimated number of sample locations	Estimated total number of samples	Estimated number analyses/ per sample	Estimated total number of data points
Task 1 - Prepare	Report	1				
Task 2 - Review/approve	Report	1				
INTERIM REMEDIAL ACTIONS	Technical memos To be determined	TBD				

[a]EDMC = Environmental Data Management Center
[b]OSM = Office of Sample Management.

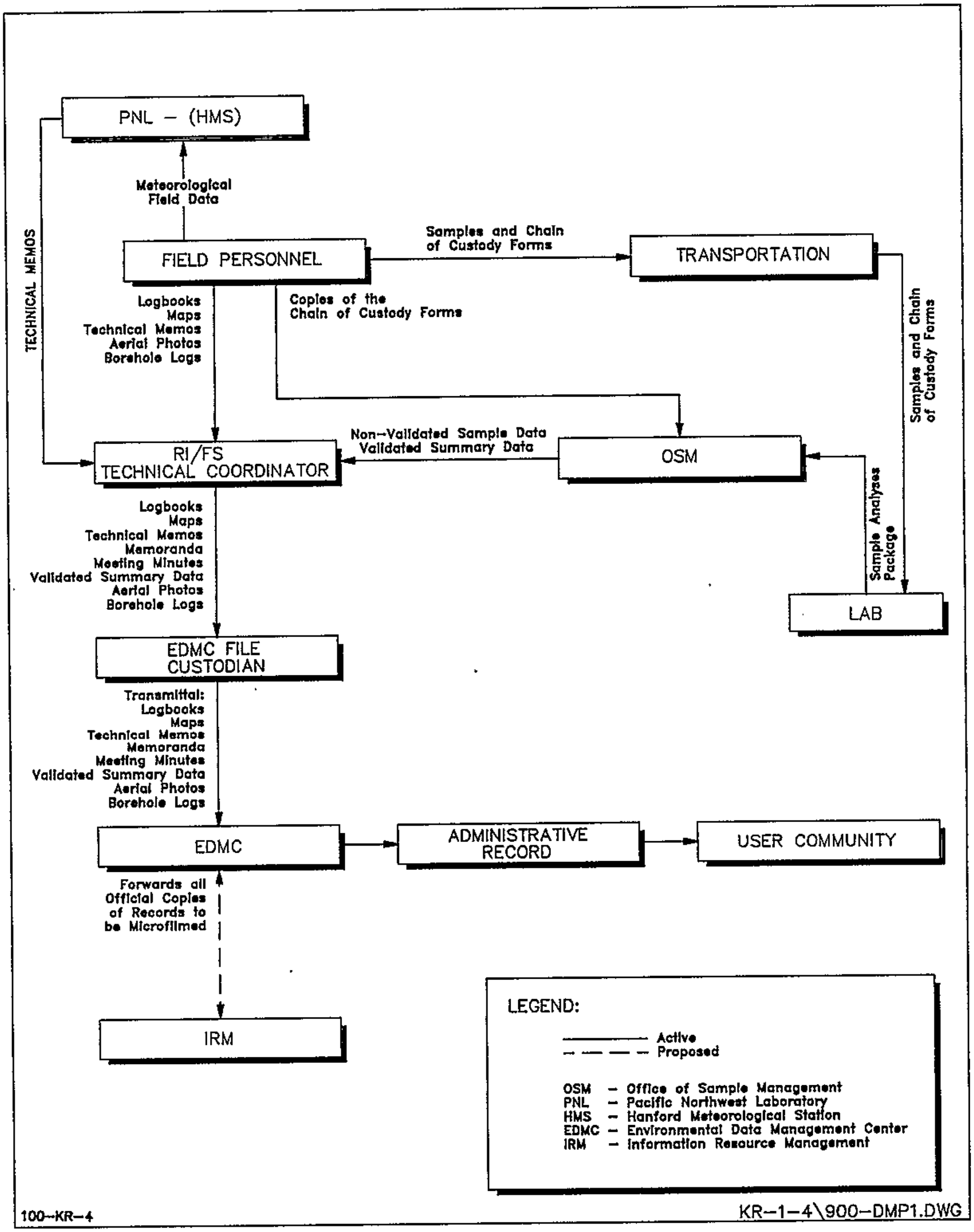

Figure DMP-1. General Data Management Plan for 100-KR-4 Work Plan Task Data.

3.2.1 Environmental Engineering Section

The Westinghouse Hanford Environmental Engineering Group provides the technical lead. The technical lead is responsible for maintaining and transmitting data to the designated storage facility.

3.2.2 Office of Sample Management

The Westinghouse Hanford OSM will validate all data packages received from the laboratory. Validated summary data will be forwarded to the technical lead for use and submittal to the EDMC. Nonvalidated or preliminary data will be forwarded to the technical lead upon request. Preliminary data will be clearly labeled as such. The OSM will maintain raw sample data, QA/QC laboratory data and the archived sample index. The OSM is scheduled to develop written data management procedures in 1990.

3.2.3 Environmental Data Management Center

The EDMC is the Westinghouse Hanford Environmental Division's central facility and service that provides a file management system for processing environmental information. The EDMC manages and controls the Administrative Record and the Administrative Record Public Access Room. Data transmittal to the EDMC is governed by the following procedures:

- EII 1.6, Records Management (WHC 1989)
- TPA-AP-06-R0, Predecisional Draft, *Clearance and Release of Administrative Record Documentation*, (DOE-RL et al. 1990a)
- TPA-AP-07-R0, Predecisional Draft, *Information Transmittals and Receipt Control*, (DOE-RL et al. 1990b)
- TPA-AP-10-R0, *Administrative Record Management*, (DOE-RL et al. 1990c)
- WHC-EP-0219, *Environmental Information Management Plan*, (Steward 1989).

Procedures addressing record control before transmittal to EDMC will be developed in FY 1990.

3.2.4 Information Resource Management

The Information Resource Management (IRM) is the designated records custodian (permanent storage) for Westinghouse Hanford. The procedural link between the EDMC and the IRM is being developed.

3.2.5 Hanford Environmental Health Foundation

The HEHF performs the analyses on the nonradiological health and exposure data and forwards summary reports to the Fire and Protection Group and the Environmental Health and Pesticide Services Section (EHPSS) within the Westinghouse Hanford Environmental Division. Nonradiological and health exposure data are maintained also for other site contractors (Pacific Northwest Laboratory [PNL] and Kaiser Engineers Hanford [KEH]) associated with 100-KR-4 operable unit activities. The HEHF provides summary data to the appropriate site contractor. The preparation of health and safety plans addressed in EII 2.1 and occupational health monitoring is covered in EII 2.2 (WHC 1988). Data management procedures are currently under development.

3.2.6 Environmental Health and Pesticide Services Section

The Westinghouse Hanford EHPSS maintains personal protection equipment fitting records and maintains nonradiological health field exposure and exposure summary reports provided by HEHF for Westinghouse Hanford Environmental Division and subcontractor personnel.

3.2.7 Technical Training Support Section

The Westinghouse Hanford technical training support section provides training and maintains training records (see Section 3.3.4).

3.2.8 Pacific Northwest Laboratory

The PNL operates the Hanford Meteorological Station (HMS) that collects and maintains meteorological data. Additionally, PNL collects and maintains radiation exposure data. Data management is discussed in the *Hanford Meteorological Data Collection System and Data Base* (Andrews 1988).

3.3 DATABASES

This section addresses databases that will receive data generated from 100-KR-4 operable unit activities.

3.3.1 Meteorological Data

The HMS, controlled by PNL, collects and maintains meteorological data. This database contains meteorological data dating from 1943 to present. The *Hanford Meteorological Data Collection System and Data Base* (Andrews 1988) is the document that explains meteorological data management.

3.3.2 Nonradiological Exposure and Medical Records

The HEHF collects and maintains data for all nonradiological exposure records and medical records.

3.3.3 Radiological Exposure Records

The PNL collects and maintains data on occupational radiation exposure. This database contains respiratory personnel protection equipment fitting records, work restrictions, and radiation exposure information.

3.3.4 Training Records

Training records for Westinghouse Hanford and subcontractor personnel are managed by the Westinghouse Hanford technical training support section. Other Hanford Site contractors (PNL and KEH) maintain their own personnel training records.

3.3.5 Environmental Information/ Administrative Record

Westinghouse Hanford EDMC personnel manage environmental information and the Administrative Record. The Administrative Record provides an index and key information on all data transmitted to the EDMC. This database is used to assist in data retrieval and to produce index lists as required.

3.3.6 Sample Status Tracking

The OSM maintains the sample status tracking database, which contains the following information about each sample: sample number, shipment data, receipt data, and laboratory identification.

4.0 ENVIRONMENTAL INFORMATION MANAGEMENT PLAN

The EIMP (Steward 1989) was issued in March 1989 and is currently under review. The EIMP is expected to be revised and expanded in FY 1990. The first part of the EIMP provides an overview of the Westinghouse Hanford Environmental Division's working files management system and addresses the management of information transmitted to the EDMC, the Environmental Division's designated file manager, in support of Environmental Restoration Program activities. An overview is presented of the EDMC's location, operating mechanics, field file support services, automated support services, and the composition and compilation of an agency-required Administrative Record.

The second part of the EIMP addresses future plans for management of scientific and technical data. The planning and control activities affecting data are discussed. These activities include data collection, analysis, integration, transfer, storage, retrieval, and presentation.

5.0 HANFORD ENVIRONMENTAL INFORMATION SYSTEM

5.1 OBJECTIVE

The HEIS is being developed by PNL for Westinghouse Hanford as a primary resource for computerized storage, retrieval, and analysis of quality-assured technical data associated with CERCLA RI/FS activities and *Resource Conservation and Recovery Act of 1976* (RCRA) Racility Investigation/Corrective Measure Study (RFI/CMS) activities being undertaken at the Hanford Site. The HEIS will provide a means for interactive access to data sets. Implementation of HEIS will serve to facilitate data consistency, quality, traceability, and security within a single controlled database. The HEIS is expected to be operational by September 1990.

The following is a list of data subjects proposed to be entered into HEIS:

- Geologic
- Geophysics
- Atmospheric
- Biotic
- Site characterization
- Soil gas
- Waste site information
- Surface monitoring
- Ground water.

Existing databases that are proposed to be incorporated, in whole or in part, within HEIS include the Waste Information Data System (WIDS), and the Hanford Ground Water Database.

Considerable resources are being devoted to completing development and to implementing HEIS in FY 1990. The HEIS is accompanied by a detailed operator and procedure manual that is being prepared by PNL for Westinghouse Hanford.

5.2 INTEGRATION OF 100-KR-4 DATA INTO HEIS

All data collected before the implementation of HEIS will be handled and stored according to the DMP described in Section 3.0. Figure DMP-2 outlines the general data management for data collected after implementation of HEIS. Data collected before implementing HEIS will be entered eventually into HEIS as time and resources allow.

6.0 REFERENCES

Andrews, G. L., 1988, *Hanford Meteorological Data Collection System and Data Base*, PNL-6509, Pacific Northwest Laboratory, Richland, Washington.

DOE-RL, EPA, and Ecology, 1990a, *Clearance and Release of Administrative Record Documentation*, TPA-AP-06-R0, Predecisional draft, U.S. Department of Energy-Richland Operations Office, U.S. Environmental Protection Agency, and Washington State Department of Ecology, Richland, Washington.

DOE-RL, EPA, and Ecology, 1990b, *Information Transmittals and Receipt Control*, TPA-AP-07-R0, Predecisional draft, U.S. Department of Energy-Richland Operations Office, U.S. Environmental Protection Agency, and Washington State Department of Ecology, Richland, Washington.

DOE-RL, EPA, and Ecology, 1990c, *Administrative Record Management*, TPA-AP-10-R0, Predecisional draft, U.S. Department of Energy-Richland Operations Office, U.S. Environmental Protection Agency, and Washington State Department of Ecology, Richland, Washington.

Steward, J. C., 1989, *Environmental Information Management Plan*, WHC-EP-0219, Westinghouse Hanford Company, Richland, Washington.

WHC, 1988, *Environmental Investigations and Site Characterizations Manual*, WHC-CM-7-7, Richland, Washington.

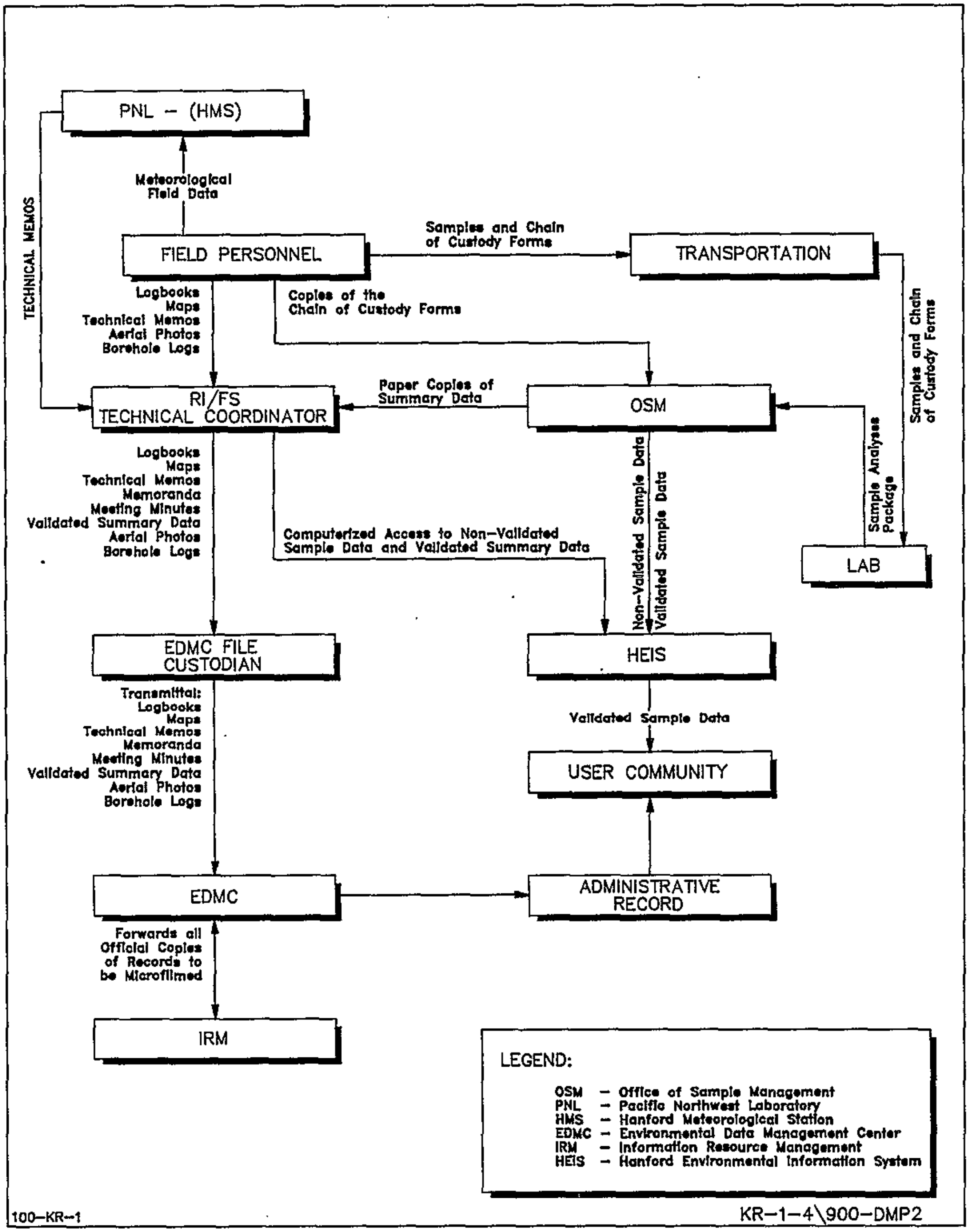

Figure DMP-2. General Data Management for 100-K-4 Work Plan Task Data After Implementation of HEIS.

Attachment 5

COMMUNITY RELATIONS PLAN

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1.0 INTRODUCTION

A community relations plan (CRP) has been developed for the Hanford Site Environmental Restoration Program. Because community relations activities are so interrelated among operable units, a decision was made to develop a single CRP that will have the capability to address specific individual concerns associated with each operable unit, but will still provide continuity and general coordination of all the Environmental Restoration Program activities with regard to community involvement. The Hanford Site-wide CRP discusses background information, history of community involvement at the Hanford Site, and community concerns regarding the Hanford Site. It also delineates the community relations program that the U.S. Department of Energy-Richland Operations Office, the U.S. Environmental Protection Agency-Region 10 Office, and the Washington State Department of Ecology will cooperatively implement throughout the cleanup of all the operable units at the Hanford Site. All community relations activities associated with the 100-KR-4 operable unit work plan will be conducted under this overall Hanford Site CRP.

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